DESCRIPTION

INFORMATION-PROCESSING DEVICE, SERVER, COMMUNICATION SYSTEM, ADDRESS DECISION METHOD, ADDRESS MODIFICATION METHOD, AND PROGRAM

TECHNICAL FIELD

The present invention relates to a communication system, in particular, to one that performs tunnel communication.

BACKGROUND ART

Conventionally, tunnel communication, in which target data are encapsulated for communication, has been developed. Such technology is disclosed in Japanese Patent Laid-Open Application No. 2003-244188 (the first and other pages, and the third and other figures).

In tunnel communication, communication target data to be encapsulated also needs its IP address to be set by an information-processing device as a communication terminal. The IP address must be set so as not to overlap among each information-processing terminal. Meanwhile, methods of allocating an address include DHCP and AutoIP.

However, an address allocation method with DHCP, AutoIP or the like uses a heuristic algorithm. In AutoIP, for instance, an address range is set in advance and the following processes are repeated: an information-processing device at the client inquires at the server if a given IP address is available or not. If the address is not being used

by another information-processing device, the address is used; otherwise, the device further inquires if still another address is available or not. This heuristic algorithm is complicated and has problems in that it takes a long time to determine an IP address to be used by an information-processing device at the client. Further, an IP address within a predetermined range is allocated by the client's information-processing device so as not to overlap, and thus the device is unable to allocate too many addresses to exceed a predetermined address range.

SUMMARY OF THE INVENTION

The present invention, in order to solve the above-mentioned problems, aims at providing a communication system and the like that determine an IP address to be used for communication target data encapsulated in tunnel communication, with a simple algorithm.

In order to achieve the above-mentioned objective, an information-processing device according to the present invention is an information-processing device for communication source that performs tunnel communication with a device for communication destination, where the information-processing device is equipped with: a tunnel communication part that encapsulates communication target data to perform tunnel communication; an identifier acceptor for accepting a communication destination device identifier for identifying a device at the communication destination; an identifier storage part that stores a communication source device identifier for identifying the information-processing device; and an address determination part for determining an address to be used for the communication target data,

according to the communication destination device identifier and the communication source device identifier.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined according to a communication destination device identifier and a communication source device identifier, with a simple algorithm. Consequently, an address does not need to be determined with DHCP or AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

An information-processing device according to the present invention is an information-processing device for communication source, that performs tunnel communication with a device for communication destination, where the information-processing device is equipped with: a tunnel communication part that performs the tunnel communication with communication target data encapsulated; a judgement part for judging whether the information-processing device is a caller or callee in the tunnel communication; and an address determination part for determining an address to be used for the communication target data, according to a determination by the judgement part.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined with a simple algorithm, according to a determination that the information-processing device is a caller or callee. Consequently, an address does not need to be determined with DHCP or AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

An information-processing device according to the present invention is an information-processing device for communication source, that performs tunnel communication with a device for communication destination, where the information-processing device is equipped with: a tunnel communication part that performs the tunnel communication with communication target data encapsulated; an identifier acceptor for accepting a communication destination device identifier for identifying a device at the communication destination; an identifier storage part that stores a communication source device identifier for identifying the information-processing device; a tunnel communication identifier acceptor for accepting a tunnel communication identifier for identifying the tunnel communication; and an address determination part for determining an address to be used for the communication target data, according to the communication destination device identifier, to the communication source device identifier, and to the tunnel communication identifier.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined with a simple algorithm, according to a communication destination device identifier, to a communication source device identifier, and to a tunnel communication identifier. Consequently, an address does not need to be determined with DHCP or AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

An information-processing device according to the present invention is an information-processing device for communication source, that performs tunnel communication with a device for

communication destination, where the information-processing device is equipped with: a tunnel communication part that performs the tunnel communication with communication target data encapsulated; a judgement part for judging whether the information-processing device is a caller or callee in the tunnel communication; a tunnel communication identifier acceptor for accepting a tunnel communication identifier for identifying the tunnel communication; and an address determination part for determining an address to be used for the communication target data, according to a determination by the judgement part and the tunnel communication identifier.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined with a simple algorithm, according to a determination that the information-processing device is a caller or callee, and to a tunnel communication identifier. Consequently, an address does not need to be determined with DHCP or AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

A server according to the present invention is equipped with: an identifier acceptor for accepting a first device identifier for identifying a first information-processing device, and a second device identifier for identifying a second information-processing device; an address determination part for determining a first address of the first information-processing device and a second address of the second information-processing device, both used for communication target data encapsulated in tunnel communication performed between the first information-processing device and the second

information-processing device, according to the first device identifier and the second device identifier, both accepted by the identifier acceptor; and an address output part for outputting the first address and the second address that the address determination part has determined.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined with a simple algorithm, according to a first device identifier and a second device identifier. Consequently, an address does not need to be determined with DHCP or AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

A server according to the present invention is equipped with: a judgement part for judging which is a caller or callee, the first information-processing device or second information-processing device in tunnel communication; an address determination part for determining a first address of the first information-processing device and a second address of the second information-processing device, both used for communication target data encapsulated in tunnel communication performed between the first information-processing device and the second information-processing device, according to a determination by the judgement part; and an address output part for outputting the first address and the second address that the address determination part has determined.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined with a simple algorithm, according to a determination that the first

information-processing device or second information-processing device is a caller or callee. Consequently, an address does not need to be determined with DHCP or AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

A server according to the present invention is equipped with: an identifier acceptor for accepting a first device identifier for identifying a first information-processing device, and a second device identifier for identifying a second information-processing device; a tunnel communication identifier acceptor for accepting a tunnel communication identifier for identifying tunnel communication performed between the first information-processing device and the second information-processing device; an address determination part for determining a first address of the first information-processing device and a second address of the second information-processing device, both used for communication target data encapsulated in tunnel communication performed between the first information-processing device and the second information-processing device, according to the first device identifier and the second device identifier, both accepted by the identifier acceptor, and a tunnel communication identifier accepted by the tunnel communication identifier acceptor; and an address output part for outputting the first address and the second address that the address determination part has determined.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined with a simple algorithm, according to a first device identifier, to a second device

identifier, and to a tunnel communication identifier. Consequently, an address does not need to be determined with DHCP or AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

A server according to the present invention is equipped with: a judgement part for judging which is a caller or callee, the first information-processing device or second information-processing device in tunnel communication; a tunnel communication identifier acceptor for accepting a tunnel communication identifier for identifying tunnel communication performed between the first information-processing device and the second information-processing device; an address determination part for determining a first address of the first information-processing device and a second address of the second information-processing device, both used for communication target data encapsulated in tunnel communication performed between the first information-processing device and the second information-processing device, according to a determination by the judgement part and a tunnel communication identifier accepted by the tunnel communication identifier acceptor; and an address output part for outputting the first address and the second address that the address determination part has determined.

With such a makeup, an address to be used for communication target data in tunnel communication can be determined with a simple algorithm, according to a determination that the first information-processing device or second information-processing device is a caller or callee, and to the tunnel communication identifier. Consequently, an address does not need to be determined with DHCP or

AutoIP, both using a heuristic algorithm, thus dispensing with a DHCP server and the like in a communication system.

A server according to the present invention is equipped with: an address agreement information receiver for receiving address agreement information showing that two or more addresses agree that are used for communication target data encapsulated in two or more tunnel communications; an address change information composition part for composing address change information that is related to address change, so as to resolve the address agreement; an address change information transmitter for transmitting the address change information.

With such a makeup, if it is detected in two or more tunnel communications that two or more addresses used for communication target data agree, the two or more addresses can be resolved by composing and transmitting address change information.

In this way, an information-processing device and others according to the present invention allow an address used for communication target data encapsulated in tunnel communication to be determined with a simple method.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows the makeup of a communication system according to embodiment 1 of the present invention.

Fig. 2 is a block diagram showing the makeup of a first information-processing device according to the embodiment.

Fig. 3 is a block diagram showing the makeup of a second information-processing device according to the embodiment.

Fig. 4 is a flowchart showing the action of the first information-processing device in the embodiment.

Fig. 5A shows a data structure in the embodiment.

Fig. 5B shows a data structure in the embodiment.

Fig. 6 shows a table that is an example of correspondence between a digit number of a device in the embodiment and an IP address.

Fig. 7 shows the makeup of a first information-processing device according to embodiment 2 of the present invention.

Fig. 8 shows the makeup of a second information-processing device according to the embodiment.

Fig. 9 shows the makeup of a communication system according to embodiment 3 of the present invention.

Fig. 10 is a flowchart showing the action of a server in the embodiment.

Fig. 11 shows an example of correspondence between a device identifier in the embodiment and an IP address.

Fig. 12 is a block diagram showing the makeup of a first information-processing device according to embodiment 4 of the present invention.

Fig. 13 is a block diagram showing the makeup of a second information-processing device according to the embodiment.

Fig. 14 is a flowchart showing the action of a first information-processing device in the embodiment.

Fig. 15A shows a table that is an example of correspondence between a caller and a callee in the embodiment, and an IP address.

Fig. 15B shows a table that is an example of correspondence between a caller and a callee in the embodiment, and an IP address.

Fig. 16 shows the makeup of a communication system according to embodiment 5 of the present invention.

Fig. 17 shows the makeup of a communication system according to embodiment 6 of the present invention.

Fig. 18 is a flowchart showing the action of a server in the embodiment.

Fig. 19 is a block diagram showing the makeup of a first information-processing device according to embodiment 7 of the present invention.

Fig. 20 is a block diagram showing the makeup of a server according to the embodiment.

Fig. 21 is a flowchart showing the action of a first information-processing device in the embodiment.

Fig. 22A shows an example of the makeup of an address in the embodiment.

Fig. 22B shows a table that is an example of correspondence between a digit number of a device identifier in the embodiment and an IP address.

Fig. 23 shows the makeup of a communication system according to embodiment 8 of the present invention.

Fig. 24 shows the makeup of a communication system according to embodiment 9 of the present invention.

Fig. 25 is a flowchart showing the action of a server in the embodiment.

Fig. 26 is a block diagram showing the makeup of a first information-processing device according to embodiment 10 of the present invention.

Fig. 27 is a flowchart showing the action of a first information-processing device in the embodiment.

Fig. 28A shows an example of the makeup of an address in the embodiment.

Fig. 28B shows a table that is an example of correspondence between a caller or callee and a host address in the embodiment.

Fig. 28C shows a table that is an example of correspondence between a caller or callee and a host address in the embodiment.

Fig. 29 shows the makeup of a communication system according to embodiment 11 of the present invention.

Fig. 30 shows the makeup of a communication system according to embodiment 12 of the present invention.

Fig. 31 is a flowchart showing the action of a server in the embodiment.

Fig. 32 shows the makeup of a communication system according to embodiment 13 of the present invention.

Fig. 33 is a block diagram showing the makeup of a first information-processing device according to the embodiment.

Fig. 34 is a block diagram showing the makeup of a third information-processing device according to the embodiment.

Fig. 35 is a flowchart showing the action of a first information-processing device in the embodiment.

Fig. 36 is a block diagram showing the makeup of a first information-processing device according to embodiment 14 of the present invention.

Fig. 37 is a block diagram showing the makeup of a second information-processing device according to the embodiment.

Fig. 38 is a flowchart showing the action of a first information-processing device in the embodiment.

Fig. 39 is a flowchart showing the action of a second information-processing device in the embodiment.

Fig. 40 is a block diagram showing the makeup of a first information-processing device according to embodiment 15 of the present invention.

Fig. 41 is a block diagram showing the makeup of a second information-processing device according to the embodiment.

Fig. 42 is a block diagram showing the makeup of a server according to the embodiment.

Fig. 43 is a flowchart showing the action of a server in the embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

(Embodiment 1)

A description is made for a communication system according to embodiment 1 of the present invention, referring to drawings.

Fig. 1 shows the makeup of a communication system according to the embodiment. In Fig. 1, the communication system according to the embodiment is provided with: first information-processing device 1, second information-processing device 2, and server 4, all connected one another via wired or wireless communication line 3. Communication line 3 is the Internet, for example. In this embodiment, an address used for communication target data encapsulated in tunnel communication is to be determined by first information-processing device 1.

Fig. 2 is a block diagram showing the makeup of first information-processing device 1. In Fig. 2, first information-processing device 1 is equipped with tunnel communication part 11, identifier acceptor 12, identifier storage part 13, address determination part 14, and address transmitter 15.

Tunnel communication part 11 performs tunnel communication between first information-processing device 1 and second information-processing device 2. Here, tunnel communication refers to communication performed with communication target data encapsulated. Tunnel communication part 11 performs actions such as encapsulation of communication target data, and release of a capsule for encapsulated data having been transmitted. Encapsulation refers to encompassing communication target data with a header or the like prescribed by a protocol. Communication target data to be encapsulated may be optionally encrypted. Examples for tunnel communication include UDP tunnel communication, HTTP tunnel communication, and L2TP tunnel communication. Here, tunnel communication part 11 may optionally include a communication device (e.g. modem and network card).

In this case, a communication device (not illustrated) may exist between tunnel communication part 11 and communication line 3, or software for passing data to the communication device may exist. Tunnel communication part 11 may be implemented with hardware, or software such as a driver for driving the communication device. Further, tunnel communication part 11 may acquire communication target data, for example, by reading from a given recording medium (e.g. DVD and hard disk), or may acquire communication target data by

accepting data transmitted or input from a given device.

Identifier acceptor 12 accepts a communication destination device identifier for identifying a device for communication destination, namely second information-processing device 2. Here, identifier acceptor 12 may accept a communication destination device identifier having been input from an input device (e.g. keyboard, mouse, or touch panel), may accept a communication destination device identifier having been transmitted via wired or wireless communication lines, or may accept a communication destination device identifier having been read from a given recording medium (e.g. optical disc, magnetic disk, or semiconductor memory).

Identifier storage part 13 stores a communication source device identifier for identifying a device for communication source, namely first information-processing device 1. Here, identifier storage part 13 can be implemented with a given recording medium (e.g. semiconductor memory, magnetic disk, or optical disc). Storage in identifier storage part 13 may be temporary storage such as a RAM indicated by a communication source device identifier read from an external storage device, for example, or long-term storage such as a ROM.

In this embodiment, first information-processing device 1 is regarded as a communication source, with first information-processing device 1 as the reference device, and second information-processing device 2 is regarded as a communication destination. Therefore, the device identifier for identifying first information-processing device 1 is referred to as a communication source device identifier, while the device identifier for identifying second information-processing device 2 is referred to as a communication destination device identifier.

However, a communication destination and a communication source are expediential, and thus both may be swapped if, for example, second information-processing device 2 is the reference device. For instance, a device identifier for identifying a first information-processing device may be referred to as a communication destination device identifier.

In addition, the communication destination device identifier and communication source device identifier are different each other, and GUID (global unique ID) such as a MAC address or EUI64-based address may be used.

Address determination part 14 determines an address (sometimes called "virtual interface address" or "tunnel mode address") used for communication target data encapsulated in tunnel communication, according to a communication destination device identifier accepted by identifier acceptor 12, and to a communication source device identifier stored in identifier storage part 13. It is sufficient if the address used for a device for communication destination (namely, second information-processing device 2) and a device for communication source (namely, first information-processing device 1) are determined so that they are different each other, according to the communication destination device identifier and communication source device identifier. Methods of determining an address include one with a given function used, and one by selecting from a plurality of predetermined addresses. The latter method includes one with a given table used, and one that compares a communication destination device identifier with a communication source device identifier, and determines according to the comparison result. A concrete example of a method of determining an address is described hereinafter. In

determining addresses, an address for a device for communication source and/or one for communication destination may be determined. In this embodiment, a description is made for a case where both addresses for a communication source and communication destination are determined.

Address transmitter 15 transmits an address determined at address determination part 14. This transmitting may be made either to second information-processing device 2, to server 4, or to another device administrating addresses. If the transmitting is performed to server 4 or the like, the address may be passed from server 4 or the like to second information-processing device 2, directly (by transmitting, for example), or indirectly (by transmitting via another server or recording medium, for example). A target address to be transmitted may be only the address for a device for communication destination (namely, second information-processing device 2), or may include the one for a communication source (namely, first information-processing device 1). Still, address transmitter 15 may optionally include a transmission device (e.g. modem and network card). In this case, a communication device (not illustrated) may exist between address transmitter 15 and communication line 3, or software or the like for passing data to the communication device may exist. Address transmitter 15 may be implemented with hardware, or software such as a driver for driving the transmission device.

Fig. 3 is a block diagram showing the makeup of second information-processing device 2. In Fig. 3, second information-processing device 2 is equipped with address acceptor 21, tunnel communication part 22, and identifier storage part 23.

Address acceptor 21 accepts an address used for communication target data in tunnel communication. Address acceptor 21, for example, may accept an address having been input from an input device (e.g. keyboard, mouse, or touch panel), may accept an address transmitted through wired or wireless communication lines, or may accept an address having been read from a given recording medium (e.g. optical disc, magnetic disk, or semiconductor memory). In this embodiment, an address transmitted from first information-processing device 1 is to be accepted.

Tunnel communication part 22 performs tunnel communication with first information-processing device 1. In the tunnel communication, an address accepted by address acceptor 21 is used as an address used for communication target data. The other makeup is the same as that of tunnel communication part 11, and thus its description is omitted.

Identifier storage part 23 stores a communication destination device identifier for identifying a device for communication destination, namely second information-processing device 2. Here, identifier storage part 23 is the same as identifier storage part 13 in first information-processing device 1, except that it stores a communication destination device identifier instead of a communication source device identifier, and thus its description is omitted.

Server 4 performs processes related to establishing tunnel communication between first information-processing device 1 and second information-processing device 2. One such example is that server 4 notifies first information-processing device 1 of the address of second information-processing device 2.

Next, a description is made for the action of a communication system, in particular the action for determining an address by first information-processing device 1, according to this embodiment. Fig. 4 is a flowchart showing the action for determining an address in first information-processing device 1.

(S101) Identifier acceptor 12 judges whether a communication destination device identifier has been accepted or not. If accepted, the process passes the communication destination device identifier to address determination part 14, and then the flow goes to S102; otherwise, the action of S101 is repeated.

(S102) Address determination part 14 determines an address used for communication target data in tunnel communication, according to a communication source device identifier stored in identifier storage part 13, and to a communication destination device identifier accepted by identifier acceptor 12, and then passes the determined address to tunnel communication part 11 and address transmitter 15.

(S103) Address transmitter 15 transmits an address determined by address determination part 14 to second information-processing device 2, and then the flow returns to S101.

In the flowchart of Fig. 4, the process ends with an interruption of power off or process end. Also, this flowchart illustrates a case where processes such as determining an address are performed when identifier acceptor 12 accepts a communication destination device identifier. However, such timing is not limited to this case, but an address may be determined when tunnel communication part 11 starts tunnel communication with second information-processing device 2, using a communication destination device identifier having been

accepted by that time, for example.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the makeup of data in tunnel communication is described using Fig. 5. Fig. 5 shows an example of communication target data before being encapsulated (Fig. 5A) and that after being encapsulated (Fig. 5B).

In Fig. 5A, the communication target data includes IP header 101, TCP/UDP header 102, and payload 103. An address determined by address determination part 14 is used as an IP address used in IP header 101. TCP/UDP header 102 may be a header for either TCP or UDP. Payload 103 includes communication target data itself, namely information to be actually used by application software in first information-processing device 1, second information-processing device 2, and others.

Fig. 5B shows data that is a UDP-encapsulated original packet (communication target data) shown in Fig. 5A. In Fig. 5B, the original packet is encrypted by adding an administration header (XX header 203) and a trailer (XX trailer 204) to the original packet, and is encapsulated by adding UDP header 202 and IP header 201. IP addresses used in IP header 201 are those of first information-processing device 1 and second information-processing device 2.

Next, a description is made for processes such as acquiring an address before starting communication between first information-processing device 1 and second information-processing device 2. In this concrete example, the IP address of first information-processing device 1 is to be "202.132.10.6", and then the

communication source device identifier is to be "12345678". The IP address of second information-processing device 2 is to be "131.206.10.240", and the communication destination device identifier is to be "98765432". Still, the IP address of server 4 is to be "155.32.10.10".

Tunnel communication part 11 in first information-processing device 1 is to retain the IP address of server 4 in advance, and transmits the communication source device identifier "12345678" stored in identifier storage part 13 to the IP address "155.32.10.10" of server 4. Then the communication source device identifier is received by server 4. In addition, server 4 acquires the IP address "202.132.10.6" of first information-processing device 1, from the header of the communication source device identifier transmitted. Server 4 retains the IP address "202.132.10.6" of first information-processing device 1, and the communication source device identifier "12345678", making both correspond.

In the same way, tunnel communication part 22 in second information-processing device 2 transmits the communication destination device identifier "98765432" stored in identifier storage part 23 to server 4. Consequently, server 4 retains the IP address "131.206.10.240" of second information-processing device 2, and the communication destination device identifier "98765432", making both correspond.

If a user is assumed to attach a detachable recording medium with a communication destination device identifier recorded therein into a slot (not illustrated) of first information-processing device 1, and the communication destination device identifier "98765432" recorded on

the recording medium is accepted by identifier acceptor 12 to be passed to address determination part 14 and tunnel communication part 11 (S101).

Tunnel communication part 11 transmits to server 4, the communication destination device identifier "98765432" received from identifier acceptor 12, and an instruction of transmitting the IP address of the device identified by the communication destination device identifier. Server 4 then receives them to transmit the IP address "131.206.10.240" being retained to first information-processing device 1, corresponding to the communication destination device identifier "98765432".

Tunnel communication part 11 in first information-processing device 1 , when accepting the IP address "131.206.10.240" of second information-processing device 2 from server 4, retains the IP address.

Address determination part 14, when receiving a communication destination device identifier from identifier acceptor 12, reads a communication source device identifier stored in identifier storage part 13, and determines an IP address used for communication target data in tunnel communication, according to the communication destination device identifier and communication source device identifier. Specifically, address determination part 14 determines an address with one of the following three methods, for example (S102).

[Method of Determining an Address Using a Function]

Address determination part 14 has the function "Func (argument 1, argument 2)" for determining an address, where the communication source device identifier "12345678" is substituted for argument 1, and the communication destination device identifier "98765432" for

argument 2. Consequently, the two IP addresses "192.168.0.1" and "192.168.0.2" are derived by calculation. Then, the former IP address "192.168.0.1" is determined as that for first information-processing device 1, and the latter "192.168.0.2" for second information-processing device 2. They are passed to tunnel communication part 11 and address transmitter 15.

[Method of Determining an Address Using a Table]

Address determination part 14 has the table shown by Fig. 6, which shows correspondence between a digit number where the device identifier is different and an IP address.

Address determination part 14 determines IP addresses corresponding to the values ("2" and "8") of the least significant digits of the communication destination device identifier "98765432" and communication source device identifier "12345678”, as IP addresses for first information-processing device 1 and second information-processing device 2. In this case, the IP address for first information-processing device 1 is "192.168.0.8", and second information-processing device 2 is "192.168.0.2". Here, if the values of the least significant digits of the communication destination device identifier and communication source device identifier are identical (both "2", for example), judgement is further made for the next digit (one digit to the left), and if they are also identical, judgement is made for the further next digit. In this way, comparison is made from the least significant digit in order for the communication destination device identifier and communication source device identifier, and then IP addresses are determined at the digit with different values, using the table of Fig. 6. The determined IP addresses for first

information-processing device 1 and second information-processing device 2, namely "192.168.0.8" and "192.168.0.2" are passed to tunnel communication part 11 and address transmitter 15.

[Method of Determining an Address by Magnitude Comparison of Device Identifiers]

Address determination part 14 has the IP addresses "192.168.0.1" and "192.168.0.2", corresponding to those for the smaller and larger device identifiers, respectively. Comparison is made for the communication destination device identifier "98765432" and communication source device identifier "12345678", and then the IP address "192.168.0.2" is allocated to the larger one, and "192.168.0.1" to the smaller. Consequently, the IP address for first information-processing device 1 is determined as "192.168.0.1", and second information-processing device 2 as "192.168.0.2". Address determination part 14 passes these determined addresses to tunnel communication part 11 and address transmitter 15.

Here, the description is made for a case of magnitude comparison of device identifiers. However, an address may be determined in the following way. That is, another method of comparison is made with a given algorithm, and then selection is made from a plurality of (usually two) predetermined addresses.

One example is that magnitude comparison is made for the least significant digit (if both values of the least significant digits are identical, a digit with different values, closest to the least significant one), and then an address is selected according to the comparison result. Another example is, if a device identifier is composed of alphabetical characters, to judge which device identifier is closer to "A"

in so-called lexicographic order (in other words, the identifier is listed earlier in a dictionary).

In the above-mentioned concrete example, the description is made for three different methods of determining addresses. However, it is sufficient if address determination part 14 determines an address according to two device identifiers, and thus another method of determining addresses may be used. For example, instead of using a table, the values of the least significant digit of a communication source device identifier and a communication destination device identifier may be substituted for a given function to calculate an IP address.

Address transmitter 15 transmits the IP address (to be “192.168.0.1”) of first information-processing device 1 and the IP address (to be “192.168.0.2”) of second information-processing device 2, both determined by address determination part 14, to the IP address "131.206.10.240" of second information-processing device 2, retained by tunnel communication part 11 (S103). Consequently, these IP addresses are accepted by address acceptor 21 in second information-processing device 2 and passed to tunnel communication part 22. Here, the IP addresses to be transmitted are to be identified as for first information-processing device 1 or second information-processing device 2, by second information-processing device 2. One example is that a corresponding information-processing device may be predetermined according to the order of IP addresses to be transmitted. Alternatively, information or flags for identifying an information-processing device, corresponding to the IP address, are transmitted, and a corresponding information-processing device may

be predetermined according to the information or flags.

Tunnel communication part 11, when receiving the IP address "192.168.0.1" of first information-processing device 1 and "192.168.0.2" of second information-processing device 2, from address determination part 14, performs tunnel communication using these addresses. In other words, in IP header 101, "192.168.0.1" is used as the IP address of the communication source (namely, first information-processing device 1), and "192.168.0.2" as the communication destination (namely, second information-processing device 2). Here, in IP header 201 of the packet (illustrated in Fig. 5B) that is the communication target data having been encapsulated, "202.132.10.6" is used as the IP address of the communication destination, and "131.206.10.240" as the communication source. Similarly, in IP header 101 for the second information-processing device 2, "192.168.0.1" is used as the IP address of first information-processing device 1, and "192.168.0.2" as second information-processing device 2. Further, in IP header 201, "131.206.10.240" is used as the IP address of the communication destination (namely, second information-processing device 2), and "202.132.10.6" as the communication source (namely, first information-processing device 1). In such a way, communication is performed between first information-processing device 1 and second information-processing device 2.

This concrete example describes a case for UDP tunnel communication. However, tunnel communication is not limited to this type, but it may be HTTP tunnel communication and others as mentioned above. Also, the data structure is not limited to that in Fig. 5.

As mentioned above, the communication system according to this embodiment determines addresses used for communication target data in tunnel communication, according to a communication destination device identifier and communication source device identifier. Therefore, addresses can be determined with a deterministic algorithm, which is simpler than a heuristic algorithm. As a result, inquiries to a server and others are not required, enabling addresses to be determined in a short time. Meanwhile, an address to be used for communication target data encapsulated in tunnel communication is different from that used in communication via communication line 3, and thus for a different tunnel communication (namely, tunnel communication with a different set of information-processing devices for communication source and destination), the same address can be used. This has an advantage of unlimited number of allocation addresses, unlike in cases with DHCP or AutoIP.

In this embodiment, the description is made for a makeup where first information-processing device 1 is equipped with address transmitter 15. However, first information-processing device 1 may have an address output part for outputting an address determined by address determination part 14, instead of address transmitter 15. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The

address having been output may be set in second information-processing device 2, for example, by being recorded on a given recording medium, or by being sent to the user of second information-processing device 2 via email, facsimile, or the like

(Embodiment 2)

A description is made for a communication system according to embodiment 2 of the present invention, referring to drawings. The communication system according to this embodiment determines an address used for communication target data in tunnel communication at the respective information-processing devices.

The communication system according to this embodiment is to be the same as that in Fig. 1, where first information-processing device 1 is to correspond to first information-processing device 1a, and second information-processing device 2 to second information-processing device 2a. Fig. 7 is a block diagram showing the makeup of first information-processing device 1a according this embodiment. First information-processing device 1a according to this embodiment is equipped with tunnel communication part 11, identifier acceptor 12, identifier storage part 13, and address determination part 14. Here, tunnel communication part 11, identifier acceptor 12, identifier storage part 13, and address determination part 14 are the same as those in embodiment 1, and thus their descriptions are omitted.

Fig. 8 is a block diagram showing the makeup of second information-processing device 2a according to this embodiment. Second information-processing device 2a according to this embodiment is equipped with identifier storage part 23, tunnel communication part 24, identifier acceptor 25, and address determination part 26. Here,

identifier storage part 23 is the same as that in embodiment 1, and thus its description is omitted. Also, tunnel communication part 24, identifier acceptor 25, and address determination part 26 are the same as tunnel communication part 11, identifier acceptor 12, and address determination part 14 in embodiment 1, respectively, and thus their descriptions are omitted.

In addition, the action for determining an address by first information-processing device 1a in this embodiment is the same as that in Fig. 4 in embodiment 1, except that it does not perform a process to transmit an address at S103, and thus its description is omitted. Also, the action for determining an address by second information-processing device 2a in this embodiment is the same as that in Fig. 4 in embodiment 1, except that it judges whether a communication source device identifier, instead of a communication destination device identifier, is accepted at S101, and it does not perform a process to transmit an address at S103, and thus its description is omitted.

Next, a description is made for the action of the communication system according to this embodiment, using an concrete example. In this concrete example, the data structure in tunnel communication is to be the same as that in Fig. 5. Also, IP addresses, device identifiers, and others, of first information-processing device 1a and others in this concrete example are to be the same as those in embodiment 1.

First, a description is made for processes such as acquiring an address before first information-processing device 1a and second information-processing device 2a start communication. The following actions are the same as those of the concrete example in embodiment 1,

and thus their descriptions are omitted. That is, first information-processing device 1a and second information-processing device 2a transmit their respective device identifiers to server 4. Consequently, server 4 retains the IP address "202.132.10.6" of first information-processing device 1a, and communication source device identifier "12345678", making both correspond; and the IP address "131.206.10.240" of second information-processing device 2a, and the communication destination device identifier "98765432", making both correspond.

Next, the actions after a detachable recording medium with a communication device identifier recorded therein is attached into a slot (not illustrated) of first information-processing device 1a, and before an IP address used for communication target data in tunnel communication is determined by first information-processing device 1a, are also the same as those of the concrete example in embodiment 1, and thus their descriptions are omitted.

Here, server 4 is assumed to transmit an IP address of second information-processing device 2a to first information-processing device 1a, and also transmits a communication source device identifier of first information-processing device 1a to second information-processing device 2a. Consequently, the communication source device identifier "12345678" is accepted by identifier acceptor 25 through tunnel communication part 24 of second information-processing device 2a. Then, identifier acceptor 25 judges that communication source device identifier has been accepted (S101) to perform an address determination process (S102). This process is performed in the same way as in the concrete example in embodiment 1, where a similar

address is determined as determined by address determination part 14 in first information-processing device 1a. One example is that the address of first information-processing device 1a is determined as "192.168.0.1", and second information-processing device 2a as "192.168.0.2".

However, when using a function to determine an address, address determination part 26, in "Func(argument 1, argument 2)", substitutes the communication destination device identifier "98765432", which is a device identifier of second information-processing device 2a, for argument 1; and communication source device identifier "12345678", which is a device identifier of first information-processing device 1a, for argument 2. This function is assumed to reverse the order of the IP addresses if argument 1 and argument 2 are swapped. Consequently, two IP addresses "192.168.0.2" and "192.168.0.1" are derived, and the former IP address is determined as one for second information-processing device 2a; the latter for first information-processing device 1a, resulting in determining in the same way as in address determination part 14.

The action of tunnel communication after this address determination is the same as that in the concrete example of embodiment 1, except that addresses are not transmitted, and thus its description is omitted.

As mentioned above, in the communication system according to this embodiment, an address used for communication target data in tunnel communication can be also determined by each information-processing device, according to a communication destination device identifier and a communication source device

identifier. Determining an address by each information-processing device dispenses with transmitting the address.

In addition, a deterministic algorithm, where a communication destination device identifier and communication source device identifier are used, even if each information-processing device determines addresses, they can be determined without contradiction. Specifically, such situation can be avoided that the addresses of first information-processing device 1a and second information-processing device 2a, both determined by first information-processing device 1a; and those of first information-processing device 1a and second information-processing device 2a, both determined by second information-processing device 2a, lose their integrity.

In this embodiment, the description is made for a case where the addresses of a communication source and destination are determined by each information-processing device. However, when only the address of the first information-processing device is determined by first information-processing device 1a, and when only the address of the second information-processing device is determined by second information-processing device 2a, for example, they may be passed to the other party's information-processing device directly or indirectly.

(Embodiment 3)

A description is made for a communication system according to embodiment 3 of the present invention, referring to drawings. In the communication system according to this embodiment, an address used for communication target data in tunnel communication is determined by a server.

Fig. 9 shows the makeup of the communication system according to

this embodiment. In Fig. 9, the communication system according to this embodiment is equipped with first information-processing device 5, second information-processing device 6, and server 7, all connected one another via communication line 3.

First information-processing device 5 is equipped with address acceptor 51 and tunnel communication part 52.

Address acceptor 51 accepts an address used for communication target data in tunnel communication performed between first information-processing device 5 and second information-processing device 6. Address acceptor 51 may, for example, accept an address having been input from an input device (e.g. keyboard, mouse, or touch panel), may accept an address transmitted through wired or wireless communication lines, or may accept an address read from a given recording medium (e.g. optical disc, magnetic disk, or semiconductor memory). In this embodiment, an address transmitted from server 7 through communication line 3 is to be accepted.

Tunnel communication part 52 performs tunnel communication between first information-processing device 5 and second information-processing device 6. Tunnel communication part 52 is assumed to retain a first device identifier for identifying first information-processing device 5, and a second device identifier for identifying second information-processing device 6. The second device identifier may be, for example, what having been input from an input device, transmitted through a given communication line, or read from a given recording medium. Here, the makeup of tunnel communication part 52 is the same as that of tunnel communication part 11 in embodiment 1, except that the first device identifier corresponds to a

communication source device identifier, and the second device identifier to the communication destination device identifier, and thus its description is omitted.

Second information-processing device 6 is equipped with address acceptor 61 and tunnel communication part 62. The address acceptor 61 and tunnel communication part 62 are the same as address acceptor 51 and tunnel communication part 52, respectively, and thus their descriptions are omitted. Here, tunnel communication part 62 does not need to retain the first device identifier.

Server 7 performs a process to establish tunnel communication performed between first information-processing device 5 and second information-processing device 6, in the same way as server 4 in embodiment 1, and also determines an address used in the tunnel communication, equipped with communication control unit 71, identifier acceptor 72, address determination part 73, and address transmitter 74.

Communication control unit 71 performs processes such as establishing tunnel communication between first information-processing device 5 and second information-processing device 6. More specifically, it transmits an address of second information-processing device 6 to first information-processing device 5, for example.

Identifier acceptor 72 accepts first device identifier and second device identifier. Identifier acceptor 72, for example, may accept a first device identifier and others having been input from an input device (e.g. keyboard, mouse, or touch panel), a first device identifier and others transmitted through wired or wireless communication lines,

or a first device identifier and others read from a given recording medium (e.g. optical disc, magnetic disk, or semiconductor memory). In this embodiment, a first device identifier and others passed from communication control unit 71 is to be accepted.

Address determination part 73 determines a first address of first information-processing device 5 and a second address of second information-processing device 6, according to a first device identifier and second device identifier accepted by identifier acceptor 72. These addresses are used for communication target data in tunnel communication. The method of determining an address is the same as that by address determination part 14 in embodiment 1, and thus its description is omitted.

Address transmitter 74 transmits a first address and second address determined by address determination part 73, to first information-processing device 5 and second information-processing device 6. This transmission may be directly performed to first information-processing device 5, or indirectly via a given server or the like.

Next, a description is made for the action of a communication system, in particular, the action for determining an address, according to this embodiment. Fig. 10 is a flowchart showing the action to determine an address by server 7.

(S201) Identifier acceptor 72 judges whether the first device identifier and second device identifier have been accepted. If accepted, the identifier are passed to address determination part 73, and then the flow goes to S202; otherwise, process S201 is repeated until they are accepted.

(S202) Address determination part 73 determines an address used for communication target data in tunnel communication, according to the first device identifier and second device identifier received from identifier acceptor 72. Then, the determined address is passed to address transmitter 74.

(S203) Address transmitter 74 transmits two addressees determined by address determination part 73, to first information-processing device 5 and second information-processing device 6, and then the flow returns to S101. In the flowchart of Fig. 10, the process ends with an interruption of power off or process end. Also, this flowchart illustrates a case where processes such as determining an address are performed when identifier acceptor 72 accepts a first device identifier and others. However, such a timing is not limited to this case, but an address may be determined when first information-processing device 5 and second information-processing device 6 start tunnel communication, using a first device identifier and others having been accepted by that time, for example.

In addition, in the flowchart of Fig. 10, the description is made for a case where a first device identifier and second device identifier are accepted simultaneously at S201. However, these device identifiers may be accepted simultaneously, or at different timings. However, it is after both device identifiers are accepted that an address is determined, which is the same as in the flowchart of Fig. 10.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. In this concrete example, the data structure in tunnel communication is assumed to be the same as in Fig. 5. Further, the IP address of first

information-processing device 5 is assumed to be "202.132.10.6", and the first device identifier, "12345678". Also, the IP address of second information-processing device 6 is assumed to be "131.206.10.240", and the second device identifier, "98765432". Still, the IP address of server 7 is assumed to be "155.32.10.10".

Tunnel communication part 52 in first information-processing device 5 is assumed to retain an IP address of server 7 in advance. Then, tunnel communication part 52 transmits the retained first device identifier "12345678" to the IP address "155.32.10.10" of server 7. Consequently, the first device identifier is received by communication control unit 71 of server 7. Then, the IP address "202.132.10.6" of first information-processing device 5 is acquired from the header of the first device identifier. Communication control unit 71 retains the IP address of the first information-processing device 5, making it correspond with the first device identifier.

In the same way, tunnel communication part 62 in second information-processing device 6 also transmits the second device identifier "98765432" to server 7. Consequently, in communication control unit 71, address identifier correspondence information, which is information with a device identifier and IP address, both corresponding, is to be retained, as shown in Fig. 11.

Next, tunnel communication part 52 of first information-processing device 5 transmits to server 7, a second device identifier for identifying second information-processing device 6, and a request to perform tunnel communication with second information-processing device 6. Consequently, the information is received by communication control unit 71. Communication control

unit 71 acquires an IP address of first information-processing device 5 from the header of a packet transmitted from first information-processing device 5, refers to address identifier correspondence information shown in Fig. 11, and acquires the first device identifier "12345678" of first information-processing device 5. Communication control unit 71 acquires the IP address "131.206.10.240" corresponding to the second device identifier "98765432" transmitted from first information-processing device 5, referring to the address identifier correspondence information. Then, communication control unit 71 passes first device identifier "12345678" and second device identifier "98765432" to identifier acceptor 72, and also transmits the IP address "131.206.10.240" of second information-processing device 6 to first information-processing device 5.

Identifier acceptor 72, when accepting the first device identifier "12345678" and second device identifier "98765432" from communication control unit 71 (S201), passes them to address determination part 73. Address determination part 73 receives these device identifiers, determines addresses according to the device identifiers, and passes the determined addresses, making them correspond to the device identifiers, to address transmitter 74 (S202). This method of determining an address is the same as that of the concrete example in embodiment 1, and thus its description is omitted.

Address transmitter 74, when receiving from address determination part 73 a set of the device identifier "12345678" and its corresponding IP address "192.168.0.1", and a set of the device identifier "98765432" and its corresponding IP address "192.168.0.2",

acquires the IP addresses of the information-processing devices corresponding to the respective IP addresses, referring to address identifier correspondence information retained in communication control unit 71. Then, address transmitter 74 transmits the two sets of the device identifiers and IP addresses to the IP address "202.132.10.6" of first information-processing device 5 and "131.206.10.240" of second information-processing device 6.

Address acceptor 51, when accepting these sets, passes them to tunnel communication part 52. Tunnel communication part 52 receives the IP address of second information-processing device 6 transmitted from communication control unit 71, and further receives a set of the IP address and device identifier accepted by address acceptor 51. Then, tunnel communication part 52 uses the IP address "192.168.0.1" corresponding to the first device identifier "12345678" of first information-processing device 5, as an IP address of the communication source (namely, first information-processing device 5) in IP header 101, and also uses the IP address "192.168.0.2" corresponding to the second device identifier "98765432" of second information-processing device 6, as an IP address of the communication destination (namely, second information-processing device 6) in IP header 101. Then, tunnel communication part 52 encapsulates the data, composes a UDP packet as shown in Fig. 5B, and transmits the packet to second information-processing device 6 to start tunnel communication.

Address acceptor 61 in second information-processing device 6 also accepts a set of an IP address and device identifier to pass them to tunnel communication part 62. Tunnel communication part 62 uses

an IP address corresponding to the second device identifier of second information-processing device 6, as an IP address of second information-processing device 6 for communication target data in tunnel communication. In this way, tunnel communication is performed between first information-processing device 5 and second information-processing device 6.

As mentioned above, in the communication system according to this embodiment, server 7 can determine an address used for communication target data in tunnel communication performed between first information-processing device 5 and second information-processing device 6, according to a communication destination device identifier and a communication source device identifier. This enables an address to be easily determined with a simple deterministic algorithm.

In this embodiment, the description is made for a case where address transmitter 74 transmits an address determined by address determination part 73. However, an address output part for outputting an address determined by address determination part 73 may be equipped instead of address transmitter 74. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The address having been output may be set in first information-processing device 5 and second

information-processing device 6, for example, by being recorded on a given recording medium, or by being sent to the user of first information-processing device 1 or second information-processing device 2 by the administrator of server 7 via email, facsimile, or the like

Further, in this embodiment, the description is made for a case where address transmitter 74 of server 7 transmits two addressees determined by address determination part 73 to second information-processing device 6. However, address transmitter 74 may transmit only the address "192.168.0.2" of second information-processing device 6 to second information-processing device 6. In this case, second information-processing device 6 can acquire an address of first information-processing device 5 from the header of encapsulated communication target data transmitted from first information-processing device 5

In addition, in this embodiment, the description is made for a case where server 7 transmits addresses of both first information-processing device 5 and second information-processing device 6. However, server 7 may transmit the address "192.168.0.1" of first information-processing device 5 to information-processing device 5 first; the address "192.168.0.2" of second information-processing device 6, to second information-processing device 6, and then server 7 may transmit an address of the other party when an inquiry related to the address of the other party in tunnel communication is made from the information-processing device.

(Embodiment 4)

A description is made for a communication system according to

embodiment 4 of the present invention, referring to drawings. The communication system according to this embodiment determines an address used for communication target data in tunnel communication, according to a determination that the information-processing device is a caller or callee.

The communication system according to this embodiment is assumed to be the same as that in Fig. 1. However, first information-processing device 1 corresponds to first information-processing device 1b, and second information-processing device 2 to second information-processing device 2b.

Fig. 12 is a block diagram showing the makeup of first information-processing device 1b according to this embodiment. First information-processing device 1b according to this embodiment is equipped with tunnel communication part 11, address determination part 14b, address transmitter 15, and judgement part 16. Here, tunnel communication part 11 and address transmitter 15 are the same as those in embodiment 1, and thus their descriptions are omitted. In addition, in first information-processing device 1b according to this embodiment, although an identifier storage part is not illustrated clearly, the device identifier of first information-processing device 1b is assumed to be stored in an accessible recording medium in tunnel communication part 11.

Address determination part 14b determines an address used for communication target data encapsulated in tunnel communication, according to a determination by judgement part 16. It is sufficient if the address used in a device for communication destination (e.g. second information-processing device 2b) and that for communication source

(e.g. first information-processing device 1b) are different each other. Methods of determining an address include one with a given function used, and one by selecting from a plurality of predetermined addresses. A concrete example of a method of determining an address is described hereinafter. In determining addresses, an address for a device for communication source and/or one for communication destination may be determined. In this embodiment, a description is made for a case where both addresses for a communication source and communication destination are determined.

Judgement part 16 judges whether first information-processing device 1b is a caller or callee in tunnel communication. It is sufficient if first information-processing device 1b is judged as a caller or callee. In other words, first information-processing device 1b may be judged as a caller or callee by judging second information-processing device 2b, which is the device at the other end, is a caller or callee. Alternatively, judgement is made for both first information-processing device 1b and second information-processing device 2b. Here, a caller and callee may be those in communication for a protocol of tunnel (namely, a protocol encompassing communication target data) in tunnel communication, or those for communication target data (namely, target data for encapsulation). In this embodiment, the former case is described. In addition, a caller is a device that starts communication, and a callee is a device that performs communication according to a call-out from an information-processing device as a caller.

Fig. 13 is a block diagram showing the makeup of second information-processing device 2b according to this embodiment. Second information-processing device 2b according to this embodiment

is equipped with address acceptor 21 and tunnel communication part 22. Here, address acceptor 21 and tunnel communication part 22 are the same as those in embodiment 1, and thus their descriptions are omitted. In addition, in second information-processing device 2b according to this embodiment, although an identifier storage part is not illustrated clearly, the device identifier of second information-processing device 2b is assumed to be stored in an accessible recording medium in tunnel communication part 22.

Next, a description is made for the action of a communication system, in particular, the action for determining an address in first information-processing device 1b, according to this embodiment. Fig. 14 is a flowchart showing the action to determine an address in first information-processing device 1b.

(S301) Tunnel communication part 11 judges whether or not to start tunnel communication. Starting this tunnel communication includes two cases: a case where first information-processing device 1b actively starts tunnel communication, and a case where tunnel communication starts according to a request from another device (second information-processing device 2b, here). In either case, tunnel communication part 11 judges that tunnel communication is to be started. If started, the flow goes to S302; otherwise, repeats process S301 until tunnel communication is started.

(S302) Judgement part 16 judges whether first information-processing device 1b is a caller or callee.

(S303) Address determination part 14b determines an address used for communication target data in tunnel communication according to a determination by judgement part 16, namely whether first

information-processing device 1b is a caller or callee.

(S304) Address transmitter 15 transmits an address determined by address determination part 14b to second information-processing device 2b. Then the flow returns to S301. Here, in the flowchart of Fig. 14, the process ends with an interruption of power off or process end. Still, this flowchart illustrates only a process for determining an address; however, it is obvious that this determined address is used for tunnel communication.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the data structure in tunnel communication is the same as that in Fig. 5 in embodiment 1. In addition, the IP addresses and device identifiers of information-processing devices and a server are assumed to be the same as those in the concrete example in embodiment 1. Further, the processes in which first information-processing device 1b and second information-processing device 2b respectively register IP addresses and device identifying information to server 4 are the same as those in embodiment 1, and thus their descriptions are omitted.

It is assumed that a detachable recording medium with a communication destination device identifier recorded therein is attached to first information-processing device 1b, and the communication destination device identifier "98765432" stored in the recording medium is accepted by an acceptor (not illustrated) and is passed to tunnel communication part 11.

Then, tunnel communication part 11 judges that tunnel communication is to be started (S301), and transmits to server 4 the received communication destination device identifier and an

instruction of transmitting an IP address of a device identified by the communication destination device identifier. Consequently, server 4 receives them, and then transmits the retained IP address "131.206.10.240", corresponding to the communication destination device identifier "98765432", to first information-processing device 1b. Tunnel communication part 11 of first information-processing device 1b, when accepting the IP address "131.206.10.240" of second information-processing device 2b from server 4, retains the IP address.

Judgement part 16 judges that first information-processing device 1b is a caller because tunnel communication part 11 is a caller in communication for a protocol of tunnel in tunnel communication (S302), and then passes the determination to address determination part 14b.

Address determination part 14b, when receiving a determination from judgement part 16, determines an IP address used for communication target data in tunnel communication according to the determination. Specifically, address determination part 14b determines an address according to, for example, any one of the following three methods (S303).

[Method of Determining an Address by a Caller and Callee]

Address determination part 14b has the table shown in Fig. 15A. The table of Fig. 15A shows correspondence between information showing a caller or callee, and IP addresses. Address determination part 14b determines an IP address of first information-processing device 1b as "192.168.0.1"using the table of Fig. 15A, because judgement part 16 has judged that first information-processing device 1b is a caller. Meanwhile, address determination part 14b determines an IP address of second information-processing device 2b as

"192.168.0.2", because second information-processing device 2b is a callee. Here, Fig. 15A shows correspondence of information showing a caller or callee with IP addresses in a tabular form. However, they may be made correspond with a means other than a tabular form.

[Method of Determining an Address by Selecting from a Plurality of Addresses]

Address determination part 14b has a table shown in Fig. 15B. The table of Fig. 15B shows correspondence between information showing a caller or callee, and IP addresses, where four IP addresses correspond to a piece of information showing a caller or callee. Therefore, address determination part 14b is to select one IP address from the four IP addresses. This selection may be made, for example, in a random order, or in a sequential order. In this concrete example, address determination part 14b determines an IP address of first information-processing device 1b as "192.168.0.1"using the table of Fig. 15B, because judgement part 16 has judged that first information-processing device 1b is a caller. Meanwhile, address determination part 14b determines an IP address of second information-processing device 2b as "192.168.0.2", because second information-processing device 2b is a callee.

[Method of Determining an Address Using a Function]

Address determination part 14b has the function "Func(argument 1)" for determining an address. When calculating an address of caller, "0" is substituted for argument 1. Consequently, the IP address "192.168.0.1" is derived. This IP address "192.168.0.1" becomes an IP address of first information-processing device 1b at the caller side. Meanwhile, when calculating an address of a callee, "1" is substituted

for argument 1. Consequently, the IP address "192.168.0.2" is derived. This IP address "192.168.0.2" becomes an IP address of second information-processing device 2b at the callee side.

Here, the description is made for three different methods of determining an address. However, it is sufficient if address determination part 14b determines an address according to a determination that the information-processing device is caller or callee, and thus an address may be determined with a method other than these methods.

Address transmitter 15, in the same way as in the concrete example in embodiment 1, transmits the determined IP addresses "192.168.0.1" of first information-processing device 1b and "192.168.0.2" of second information-processing device 2b, to second information-processing device 2b (S304). Consequently, these IP addresses are accepted by address acceptor 21 in second information-processing device 2b and passed to tunnel communication part 22. Meanwhile, tunnel communication part 11, in the same way as in the concrete example in embodiment 1, uses the determined address to perform tunnel communication, and tunnel communication part 22 uses an address accepted by address acceptor 21 to perform tunnel communication.

As mentioned above, the communication system according to this embodiment can determine an address used for communication target data in tunnel communication, according to whether the information-processing device is a caller or callee, which is a deterministic algorithm, simpler than a heuristic one. Consequently, this embodiment has the same advantage as embodiment 1.

In this embodiment, the description is made for a structure where first information-processing device 1b has address transmitter 15. However, first information-processing device 1b may have an address output part for outputting an address determined by address determination part 14b, instead of address transmitter 15. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The address having been output may be set in second information-processing device 2b, for example, by being recorded on a given recording medium, or by being sent to the user of second information-processing device 2b via email, facsimile, or the like

(Embodiment 5)

A description is made for a communication system according to embodiment 5 of the present invention, referring to drawings. In the communication system according to this embodiment, each information-processing device determines an address used for communication target data in tunnel communication, according to a determination whether an information-processing device is a caller or callee.

Fig. 16 shows the makeup of the communication system according to this embodiment. The communication system is the same as that in Fig. 1 in embodiment 1, except that it has first information-processing

device 1c instead of first information-processing device 1, and second information-processing device 2c instead of second information-processing device 2 in Fig. 16, and thus their descriptions are omitted.

In Fig. 16, first information-processing device 1c according to this embodiment is equipped with tunnel communication part 11, address determination part 14b, and judgement part 16. Here, tunnel communication part 11, address determination part 14b, and judgement part 16 are the same as those in embodiment 4, and thus their descriptions are omitted.

In Fig. 16, second information-processing device 2c according to this embodiment is equipped with tunnel communication part 22, address determination part 26c, and judgement part 27. Here, tunnel communication part 22 is the same as that in embodiment 4. Further, address determination part 26c and judgement part 27 are the same as address determination part 14b and judgement part 16, respectively, in embodiment 4, and thus their descriptions are omitted.

In addition, the action to determine an address in first information-processing device 1c is the same as shown in Fig. 14 in embodiment 4 except for the process of transmitting an address at S304, and thus its description is omitted. Also, the action to determine an address in second information-processing device 2c in this embodiment is the same as shown in Fig. 14 in embodiment 4, except that tunnel communication part 11, address determination part 14b, and judgement part 16 correspond to tunnel communication part 22, address determination part 26c, and judgement part 27, respectively, an that they do not perform a process of transmitting an

address at S304, and thus their descriptions are omitted.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. Here, it is assumed that first information-processing device 1c is a caller and second information-processing device 2c is a callee. Still, the action to determine an IP address in first information-processing device 1c is the same as that of the concrete example in embodiment 4, and thus its description is omitted.

Server 4 transmits an IP address of second information-processing device 2c to first information-processing device 1c, according to a request from first information-processing device 1c, and also transmits information showing that first information-processing device 1c is requesting tunnel communication with second information-processing device 2c, to second information-processing device 2c.

Tunnel communication part 22 of second information-processing device 2c, when receiving information transmitted from its server 4, judges that tunnel communication is to be started (S301), and judgement part 27 judges that second information-processing device 2c is a callee (S302). Consequently, address determination part 26c determines an address in the same way as in the concrete example in embodiment 4 (S303). Here, it is assumed that the IP address "192.168.0.2" of second information-processing device 2c has been determined by address determination part 26c, and that the IP address "192.168.0.1" of first information-processing device 1c has been determined.

The action in which tunnel communication is performed after this address determination is the same as that in the concrete example in

embodiment 4, except that an address is not transmitted, and thus its description is omitted.

As mentioned above, in the communication system according to this embodiment, respective information-processing devices can also determine an address used for communication target data in tunnel communication, according to a determination whether the information-processing device is a caller or callee. Each information-processing device determines its own address, thus dispensing with transmitting an address, bringing the same effect as that in embodiment 2.

In this embodiment, the description is made for a case where the addresses of a communication source and destination are determined by each information-processing device. However, if only the address of first information-processing device 1c is determined by itself, and when only the address of second information-processing device 2c is determined by itself, for example, they may be passed to the other party's information-processing device directly or indirectly.

(Embodiment 6)

A description is made for a communication system according to embodiment 6 of the present invention, referring to drawings. In the communication system according to this embodiment, an address used for communication target data in tunnel communication is determined by a server, according to a determination whether the information-processing device is a caller or callee.

Fig. 17 shows the makeup of the communication system according to this embodiment. The communication system according to this embodiment is equipped with first information-processing device 5,

second information-processing device 6, and server 7d, all connected one another via communication line 3. Here, first information-processing device 5 and second information-processing device 6 are the same as those in embodiment 3, and thus their descriptions are omitted.

Server 7d performs a process to establish tunnel communication performed between first information-processing device 5 and second information-processing device 6, in the same way as server 4 in embodiment 1, and also determines an address used in the tunnel communication, equipped with communication control unit 71, address determination part 73d, address transmitter 74, and judgement part 75. Here, communication control unit 71 and address transmitter 74 are the same as those in embodiment 3, and thus their descriptions are omitted.

Address determination part 73d determines a first address of first information-processing device 5 and a second address of second information-processing device 6, both used for communication target data in tunnel communication encapsulated in tunnel communication performed between first information-processing device 5 and second information-processing device 6, according to a determination judged by judgement part 75. The method of determining an address is the same as that by address determination part 14b in embodiment 4, and thus its description is omitted.

Judgement part 75 judges which is a caller or callee, tunnel communication performs first information-processing device 5 or second information-processing device 6. It is sufficient if first information-processing device 5 and second information-processing

device 6 are judged as a caller or callee in this determination. In other words, first information-processing device 5 may be judged as a caller or callee by judging whether second information-processing device 6 is a caller or callee. Alternatively, judgement may be made for both first information-processing device 5 and second information-processing device 6.

Next, a description is made for the action of a communication system, in particular, the action for determining an address, according to this embodiment. Fig. 18 is a flowchart showing the action to determine an address by server 7d.

(S401) Communication control unit 71 judges whether tunnel communication is to be started between first information-processing device 5 and second information-processing device 6. If started, the flow goes to S402; otherwise, repeats process S401 until tunnel communication is started.

(S402) Judgement part 75 judges whether each of first information-processing device 5 and second information-processing device is a caller or callee.

(S403) Address determination part 73d determines addresses of first information-processing device 5 and second information-processing device 6, both used for communication target data in tunnel communication, according to a determination judged by judgement part 75.

(S404) Address transmitter 74 transmits two addresses determined by address determination part 73d, to first information-processing device 5 and second information-processing device 6, and then the flow returns to S401.

In the flowchart of Fig. 18, the process ends with an interruption of power off or process end.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the data structure in tunnel communication is the same as in Fig. 5. Also, the IP addresses and device identifiers of the information-processing devices and a server are assumed to be the same as those in the concrete example in embodiment 3. Further, the processes in which first information-processing device 5 and second information-processing device 6 register their IP addresses and device identifying information to server 7d are the same as in embodiment 3, respectively, and thus their descriptions are omitted.

Next, tunnel communication part 52 of first information-processing device 5 transmits to server 7d, a second device identifier for identifying second information-processing device 6, and a request to perform tunnel communication with second information-processing device 6. Consequently, the information is received by communication control unit 71. Communication control unit 71 judges that tunnel communication is to be started (S401), acquires an IP address of first information-processing device 5 from the header of a packet transmitted from first information-processing device 5, refers to the address identifier correspondence information shown in Fig. 11, and acquires the first device identifier "12345678" of first information-processing device 5. Communication control unit 71 also acquires the IP address "131.206.10.240" corresponding to the device identifier "98765432" transmitted from first information-processing device 5, referring to the address identifier

correspondence information shown in Fig. 11. Communication control unit 71 then transmits the IP address "131.206.10.240" of second information-processing device 6 to first information-processing device 5.

Judgement part 75, because communication control unit 71 has received information transmitted from first information-processing device 5, requesting tunnel communication with second information-processing device 6, judges that first information-processing device 5 is a caller and second information-processing device 6 is a callee (S402). Judgement part 75 then passes to address determination part 73d, information showing that the information-processing device identified by the device identifier "12345678" is a caller, and "98765432" is a callee. Consequently, address determination part 73d determines an address according to the determination and passes the determined address along with its device identifier to address transmitter 74 (S403). Here, this method of determining an address is the same as that in the concrete example in embodiment 4, and thus its description is omitted.

Address transmitter 74, when receiving from address determination part 73d a set of the device identifier "12345678" and its corresponding IP address "192.168.0.1", and a set of the device identifier "98765432" and its corresponding IP address "192.168.0.2", acquires the IP addresses of the information-processing devices corresponding to the respective device identifiers, referring to address identifier correspondence information retained in communication control unit 71. Then, address transmitter 74 transmits the two sets of the device identifiers and IP addresses to the IP address

"202.132.10.6" of first information-processing device 5 and "131.206.10.240" of second information-processing device 6 (S404). The processes hereafter are the same as those in the concrete example in embodiment 3, and thus their descriptions are omitted.

As mentioned above, in the communication system according to this embodiment, server 7d can determine an address used for communication target data in tunnel communication performed between first information-processing device 5 and second information-processing device 6, according to a determination whether information-processing device is a caller or callee. This enables an address to be easily determined with a simple deterministic algorithm.

In this embodiment, the description is made for a case where address transmitter 74 transmits an address determined by address determination part 73d. However, an address output part for outputting an address determined by address determination part 73d may be equipped instead of address transmitter 74. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The address having been output may be set in first information-processing device 5 or second information-processing device 6, for example, by being recorded on a given recording medium, or alternatively by being sent to the user of second information-processing device 6 by the administrator of server 7

via email, facsimile, or others.

In this embodiment, the description is made for a case where address transmitter 74 of server 7d transmits to second information-processing device 6, two addresses determined by address determination part 73d. However, server 7d may first transmit the address "192.168.0.1" of first information-processing device 5 to first information-processing device 5, and "192.168.0.2" of second information-processing device 6 to second information-processing device 6, and then transmit the address of the other party, when an inquiry related to the address of the other party in tunnel communication is made from an information-processing device.

(Embodiment 7)

A description is made for a communication system according to embodiment 7 of the present invention, referring to drawings. The communication system according to this embodiment determines an address used for communication target data in tunnel communication, according to the device identifier of an information-processing device and a tunnel communication identifier for identifying tunnel communication.

The communication system according to this embodiment is assumed to be the same as that in Fig. 1, where first information-processing device 1 is assumed to correspond to first information-processing device 1e, and server 4 to correspond to server 4e. In addition, second information-processing device 2 is assumed to correspond to second information-processing device 2b in embodiment 4.

Fig. 19 is a block diagram showing the makeup of first

information-processing device 1e according to this embodiment. First information-processing device 1e according to this embodiment is equipped with tunnel communication part 11, identifier acceptor 12, identifier storage part 13, address determination part 14e, address transmitter 15, and tunnel communication identifier acceptor 17. Here, tunnel communication part 11, identifier acceptor 12, identifier storage part 13, address transmitter 15 are the same as those in embodiment 1, and thus their descriptions are omitted.

Address determination part 14e determines an address used for communication target data encapsulated in tunnel communication, according to a communication destination device identifier accepted by identifier acceptor 12, a communication source device identifier stored in identifier storage part 13, and a tunnel communication identifier accepted by tunnel communication identifier acceptor 17. Here, a tunnel communication identifier refers to an identifier for identifying tunnel communication performed between information-processing devices. It is sufficient if the address used in a device for communication destination (i.e. second information-processing device 2b) and that for communication source (i.e. first information-processing device 1e) are different each other in this address determination. Methods of determining an address include one with a given function used, and one by selecting from a plurality of predetermined addresses. In addition, address determination part 14e may determine a part of an address used for communication target data, according to a communication destination device identifier and communication source device identifier; the other part of the address used for the communication target data, according to a tunnel

communication identifier. A concrete example of a method of determining an address is described hereinafter. In determining addresses, an address for a device for communication source and/or one for communication destination may be determined. In this embodiment, a description is made for a case where both addresses for a communication source and communication destination are determined.

Tunnel communication identifier acceptor 17 accepts a tunnel communication identifier. Tunnel communication identifier acceptor 17 may, for example, receive a tunnel communication identifier transmitted (from server 4e, for example) via wired or wireless communication lines, may accept a tunnel communication identifier having been input to first information-processing device 1e through a given input device (e.g. keyboard, mouse, or touch panel), may accept a tunnel communication identifier read from a given recording medium (e.g. optical disc, magnetic disk, or semiconductor memory), or may accept a tunnel communication identifier generated by first information-processing device 1e. In this embodiment, a description is made for a case where accepting a tunnel communication identifier transmitted from server 4e. Here, tunnel communication identifier acceptor 17 may optionally include a device for accepting (e.g. modem or network card). Also, tunnel communication identifier acceptor 17 may be implemented by means of hardware, or software such as a driver for driving a given device.

Fig. 20 is a block diagram showing the makeup of server 4e according to this embodiment. Server 4e is equipped with tunnel communication identifier generation part 41, tunnel communication

identifier transmitter 42, and communication control unit 71. Here, communication control unit 71 is the same as that in embodiment 3, and thus its description is omitted.

Tunnel communication identifier generation part 41 generates a tunnel communication identifier. If this tunnel communication identifier can identify tunnel communication performed among a plurality of information-processing devices, that is sufficient. Therefore, a tunnel communication identifier may be a GUID (Globally Unique Identifier), for example, or may be reused for other tunnel communication after the current one ends. Tunnel communication identifier generation part 41 may generate a tunnel communication identifier by means of calculation or the like using a given function or the like, or by means of selecting from a table including a plurality of tunnel communication identifiers. However, as long as a tunnel communication identifier capable of identifying tunnel communication can be determined, whatever method may be used.

Tunnel communication identifier transmitter 42 transmits a tunnel communication identifier generated by tunnel communication identifier generation part 41, to a information-processing device performing tunnel communication identified by the tunnel communication identifier. Here, tunnel communication identifier transmitter 42, for example, may transmit a tunnel communication identifier to only devices that determine an address, or to all devices that perform tunnel communication. In this embodiment, a description is made for a case where a tunnel communication identifier is transmitted to only devices that determine an address. In addition, tunnel communication identifier transmitter 42 may optionally include

a transmission device for transmitting (e.g. modem or network card). In this case, a transmission device (not illustrated) is to exist between tunnel communication identifier transmitter 42 and communication line 3. Also, tunnel communication identifier transmitter 42 may be implemented by means of hardware, or software such as a driver for driving such a given device.

Next, a description is made for the action of a communication system, in particular, the action in which an address is determined by first information-processing device 1e, according to this embodiment. Fig. 21 is a flowchart showing the action in which an address is determined by first information-processing device 1e.

(S501) Identifier acceptor 12 judges whether a communication destination device identifier has been accepted. If accepted, the flow goes to S502; otherwise, to S503.

(S502) Address determination part 14e temporarily stores a communication destination device identifier (not illustrated) accepted by identifier acceptor 12 in a recording medium, and then the flow returns to S501.

(S503) Tunnel communication identifier acceptor 17 judges whether a tunnel communication identifier has been accepted. If accepted, the flow goes to S504; otherwise, to S505.

(S504) Address determination part 14e temporarily stores a tunnel communication identifier (not illustrated) accepted by tunnel communication identifier acceptor 17 in a recording medium, and then the flow returns to S501.

(S505) Address determination part 14e judges whether the communication destination device identifier and tunnel communication

identifier have been accepted. This judgement is made, for example, by whether the communication destination device identifier and tunnel communication identifier are stored in a recording medium (not illustrated) included in address determination part 14e. If accepted, the flow goes to S506; otherwise, returns to S501.

(S506) Address determination part 14e determines an address using a communication destination device identifier and a tunnel communication identifier, temporarily stored in a recording medium (not illustrated), and a communication source device identifier stored in identifier storage part 13. This method of determining an address is described hereinafter.

(S507) Address transmitter 15 transmits an address determined by address determination part 14e to second information-processing device 2b, and the flow returns to S501.

In the flowchart of Fig. 21, the process ends with an interruption of power off or process end. In addition, this flowchart illustrates a case where actions such as an address determination are performed when judged that communication destination device identifier and tunnel communication identifier have been accepted. However, such timing is not limited to this case, but actions such as an address determination may be performed, for example, when tunnel communication identifier acceptor 17 accepts a tunnel communication identifier. In addition, if a communication destination device identifier has not been accepted when a tunnel communication identifier is accepted, a request may be made for transmission and input of a communication destination device identifier, for example. Further, this flowchart illustrates a case where the accepted

communication destination device identifier and tunnel communication identifier are temporarily stored in a recording medium (not illustrated) included in address determination part 14e. However, the accepted communication destination identifier and others may be temporarily stored in another recording medium. Still, this flowchart illustrates only a process for determining an address; however, it is obvious that this determined address is used for tunnel communication.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the data structure in tunnel communication is the same as that in Fig. 5 in embodiment 1. Also, the IP addresses and device identifiers of an information-processing device and a server are assumed to be the same as those in the concrete example in embodiment 1. Further, the processes in which first information-processing device 1e and second information-processing device 2b respectively register IP addresses and device identifying information to server 4e are the same as those in embodiment 1, and thus their descriptions are omitted.

When a detachable recording medium with a communication destination device identifier recorded therein is attached to first information-processing device 1e, it is assumed that the communication destination device identifier "98765432" stored in the recording medium has been accepted by identifier acceptor 12, and is passed to tunnel communication part 11 and address determination part 14e (S501). Address determination part 14e temporarily stores the communication destination device identifier in a memory (not illustrated) (S502).

Tunnel communication part 11, when receiving the communication destination device identifier "98765432" from identifier acceptor 12, judges that tunnel communication is to be started, and transmits to server 4e, the received communication destination device identifier and an instruction of transmitting an IP address of a device identified by the communication destination device identifier. Consequently, server 4e receives them and transmits the retained IP address "131.206.10.240" corresponding to the communication destination device identifier "98765432" to first information-processing device 1e. Tunnel communication part 11 of first information-processing device 1e, when accepting the IP address "131.206.10.240" of second information-processing device 2b from server 4e, retains the IP address.

In addition, server 4e judges that tunnel communication is to be started between first information-processing device 1e and second information-processing device 2b. Then, tunnel communication identifier generation part 41 generates a tunnel communication identifier "111222333" for determining tunnel communication performed between first information-processing device 1e and second information-processing device 2b. Tunnel communication identifier transmitter 42 transmits the tunnel communication identifier to first information-processing device 1e that is a caller, and that determines an address. The address of first information-processing device 1e is one acquired from the header of a packet including a communication destination device identifier transmitted from first information-processing device 1e. The transmitted tunnel communication identifier "111222333" is accepted by tunnel

communication identifier acceptor 17 of first information-processing device 1e (S503). The tunnel communication identifier is passed to address determination part 14e. Address determination part 14e temporarily stores in a memory (not illustrated) a tunnel communication identifier accepted from tunnel communication identifier acceptor 17 (S504).

After that, address determination part 14e judges that communication destination device identifier and tunnel communication identifier have been accepted (S505), and determines an IP address used for communication target data in tunnel communication, according to the communication destination device identifier "98765432" and the tunnel communication identifier "111222333", temporarily stored in a memory (not illustrated) included in address determination part 14e, , and the communication source device identifier "12345678" read from identifier storage part 13. Specifically, address determination part 14e determines an address with one of the following three methods, for example (S506).

[Method of Determining an Address Using a Table]

The address determined by address determination part 14e has a structure shown in Fig. 22A. That is, the first eight bits show "169", and next eight bits, "254". The first 12 bits of the further next 16 bits indicate a network address, which uses a remainder after dividing a tunnel communication identifier by "4,096". The last four bits show a host address, which is determined using the table of Fig. 22B. The table of Fig. 22B shows correspondence between a digit number where the device identifier is different and its host address. Address determination part 14e determines a host address corresponding to the

values ("2" and "8") of the least significant digits of the communication destination device identifier "98765432" and communication source device identifier "12345678", using the table of Fig. 22B. Consequently, the host address of first information-processing device 1e is "8", and that of second information-processing device 2b is "2". The remainder "3645", after dividing the tunnel communication identifier "111222333" by "4,096", is a network address common to first information-processing device 1e and second information-processing device 2b. Therefore, address determination part 14e determines the IP address of first information-processing device 1e as "169.254.227.216". ("111000111101", which is binary notation for "3645", and "1000", which is binary notation for "8", are divided into eight bits each, "11100011" and "11011000". They are "227" and "216", respectively in decimal notation.) In the same way, address determination part 14e determines the IP address of second information-processing device 2b as "169.254.227.210". Then, address determination part 14e passes these addresses to tunnel communication part 11 and address transmitter 15. Here, if addresses are determined in this way, "255.255.255.248" is used as a subnet mask in each information-processing device. As in this way where an address is determined using a table, address determination part 14e may determine a part of an address according to a communication destination device identifier and communication source device identifier, and may determine the other part of the address according to a tunnel communication identifier.

[Method of Determining an Address Using a Function]

Address determination part 14e has the function "Func(argument

1, argument 2, argument 3)" for determining an address. The communication source device identifier "12345678" is substituted for argument 1, the communication destination device identifier "98765432" for argument 2, and the tunnel communication identifier "111222333" for argument 3. Consequently, the two addresses "192.168.0.1" and "192.168.0.2" are derived. Then, the former IP address is determined as that of first information-processing device 1e, and the latter as second information-processing device 2b. Next, address determination part 14e passes these addresses to tunnel communication part 11 and address transmitter 15.

[Method of Determining an Address according to Magnitude Comparison Between Device Identifiers]

In this method also, an address determined by address determination part 14e is assumed to have the structure shown in Fig. 22A. In addition, the method of determining a network address according to a tunnel communication identifier is assumed to be the same as "a method of determining an address using a table" aforementioned. Address determination part 14e is to allocate "2" to the host address of the information-processing device with the larger device identifier; "1", to the smaller. Therefore, the host address of first information-processing device 1e is to be "1" because the device identifier "12345678" of first information-processing device 1e is smaller than the device identifier "98765432" of second information-processing device 2b. Consequently, address determination part 14e determines the IP address of first information-processing device 1e as "169.254.227.209". Also, address determination part 14e determines the IP address of second

information-processing device 2b as "169.254.227.210". Then address determination part 14e passes these addresses to tunnel communication part 11 and address transmitter 15. Also in this case, "255.255.255.248" is to be used as a subnet mask in each information-processing device.

Hereinbefore, three different methods of determining an address are described. However, it is sufficient if address determination part 14e determines an address according to a communication source device identifier, communication destination device identifier, and tunnel communication identifier, and thus an address may be determined with a method of determining an address other than these.

Address transmitter 15, in the same way as in the concrete example in embodiment 1, transmits the determined IP addresses of first information-processing device 1e and second information-processing device 2b, to second information-processing device 2b (S507). Consequently, these IP addresses are accepted by address acceptor 21 in second information-processing device 2b and passed to tunnel communication part 22. Further, tunnel communication part 11, in the same way as in the concrete example in embodiment 1, performs tunnel communication using the determined address, and so does tunnel communication part 22 using the address accepted by address acceptor 21.

As mentioned above, the communication system according to this embodiment can determine an address used for communication target data in tunnel communication, according to the device identifier of an information-processing device performing tunnel communication, and a tunnel communication identifier for identifying tunnel

communication, which is a deterministic algorithm, simpler than a heuristic one. Consequently, this embodiment has the same advantage as embodiment 1.

In this embodiment, the description is made for a structure where first information-processing device 1e has address transmitter 15. However, first information-processing device 1e may have an address output part for outputting an address determined by address determination part 14e, instead of address transmitter 15. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The address having been output may be set in second information-processing device 2b, for example, by being recorded on a given recording medium, or by being sent to the user of second information-processing device 2b via email, facsimile, or the like

In this embodiment, a tunnel communication identifier generated by server 4e is transmitted only to first information-processing device 1e. However, the tunnel communication identifier may be transmitted to second information-processing device 2b as well as to first information-processing device 1e.

(Embodiment 8)

A description is made for a communication system according to embodiment 8 of the present invention, referring to drawings. In the

communication system according to this embodiment, respective information-processing devices determine an address used for communication target data in tunnel communication, according to a device identifier of each information-processing device and a tunnel communication identifier.

Fig. 23 shows the makeup of the communication system according to this embodiment. The communication system according to this embodiment is equipped with first information-processing device 1f, second information-processing device 2f, and server 4e. Server 4e is the same as that in embodiment 7, and thus its descriptions is omitted. However in this embodiment, server 4e is assumed to transmit the generated tunnel communication identifier to both first information-processing device 1f and second information-processing device 2f, because addresses are determined by first information-processing device 1f and second information-processing device 2f.

First information-processing device 1f is equipped with tunnel communication part 11, identifier acceptor 12, identifier storage part 13, address determination part 14e, and tunnel communication identifier acceptor 17. Here, tunnel communication part 11, identifier acceptor 12, identifier storage part 13, address determination part 14e, and tunnel communication identifier acceptor 17 are the same as those in embodiment 7, and thus their descriptions are omitted.

Second information-processing device 2f is equipped with tunnel communication part 22, identifier storage part 23, identifier acceptor 25, address determination part 26f, and tunnel communication identifier acceptor 28. Here, tunnel communication part 22 is the

same as that in embodiment 4; identifier storage part 23 and identifier acceptor 25 are the same as those in embodiment 2; and address determination part 26f and tunnel communication identifier acceptor 28 are the same as address determination part 14e and tunnel communication identifier acceptor 17 in embodiment 7, respectively, and thus their descriptions are omitted.

In addition, the action to determine an address in first information-processing device 1f is the same as shown in Fig. 21 in embodiment 7, except that the address transmission process at S507 is not performed, and thus its description is omitted. Also, the action to determine an address in second information-processing device 2f is the same as shown in Fig. 21 in embodiment 7, except that tunnel communication part 11, identifier acceptor 12, identifier storage part 13, address determination part 14e, and tunnel communication identifier acceptor 17 correspond to tunnel communication part 22, identifier acceptor 25, identifier storage part 23, address determination part 26f, and tunnel communication identifier acceptor 28, respectively, and that the address transmission process at S507 is not performed, and thus their descriptions are omitted.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. Here, the action in which an IP address is determined in first information-processing device 1f is the same as that in the concrete example in embodiment 7, and thus its description is omitted. Still, as aforementioned, a tunnel communication identifier is assumed to be transmitted to second information-processing device 2f as well as to first information-processing device 1f.

Server 4e transmits the IP address of second information-processing device 2f to first information-processing device 1f, according to a request from first information-processing device 1f, while transmitting a device identifier of first information-processing device 1f and information showing that first information-processing device 1f is requesting tunnel communication with second information-processing device 2f, to second information-processing device 2f. In addition, server 4e generates a tunnel communication identifier and transmits it to first information-processing device 1f and second information-processing device 2f.

Identifier acceptor 25 of second information-processing device 2f accepts a device identifier of first information-processing device 1f transmitted from server 4e through tunnel communication part 22 (S501). The device identifier is temporarily stored in a memory (not illustrated) in address determination part 26f (S502). Further, tunnel communication identifier acceptor 28 of second information-processing device 2f accepts through tunnel communication part 22, a tunnel communication identifier transmitted from server 4e (S503). The tunnel communication identifier is temporarily stored in a memory (not illustrated) of address determination part 26f (S504). After that, address determination part 26f judges that a device identifier and tunnel communication identifier have been accepted (S505), and the IP addresses of first information-processing device 1f and second information-processing device 2f are determined, according to a device identifier and a tunnel communication identifier, stored in a memory (not illustrated) of address determination part 26f; and a device identifier of second information-processing device 2f, read from

identifier storage part 23. These processes are the same as those in embodiment 7, and thus their descriptions are omitted.

However, if an address is determined using a function, as described in the concrete example in embodiment 2, the device identifier of second information-processing device 2f is to be substituted for argument 1, and the device identifier of first information-processing device 1f for argument 2. Further, this function is assumed to reverse the order of the IP addresses if argument 1 and argument 2 are swapped. In this case, the first address of the addresses determined by address determination part 26f using the function is to be the IP address of second information-processing device 2f, and the second to be first information-processing device 1f.

The action in which tunnel communication is performed after this address determination is the same as that in the concrete example in embodiment 7, except that an address is not transmitted, and thus its descriptions is omitted.

As mentioned above, in the communication system according to this embodiment, it is also possible that respective information-processing devices determine an address used for communication target data in tunnel communication, according to a device identifier of the information-processing device and a tunnel communication identifier. Each information-processing device determines its own address, thus dispensing with transmitting an address, bringing the same effect as that in embodiment 2.

In this embodiment, the description is made for a case where the addresses of a communication source and destination are determined

by each information-processing device. However, when only the address of first information-processing device 1f is determined by itself, and when only the address of second information-processing device 2f is determined by itself, for example, they may be passed to the other party's information-processing device directly or indirectly.

(Embodiment 9)

A description is made for a communication system according to embodiment 9 of the present invention, referring to drawings. In the communication system according to this embodiment, a server determines an address used for communication target data in tunnel communication, according to the device identifier and tunnel communication identifier of the information-processing device.

Fig. 24 shows the makeup of the communication system according to this embodiment. In Fig. 24, the communication system according to this embodiment is equipped with first information-processing device 5, second information-processing device 6, and server 7g, all connected one another via communication line 3. Here, first information-processing device 5 and second information-processing device 6 are the same as those in embodiment 3, and thus their descriptions are omitted.

Server 7g, in the same way as server 4 in embodiment 1, performs a process to establish tunnel communication performed between first information-processing device 5 and second information-processing device 6, and also determines an address used in the tunnel communication, equipped with communication control unit 71, identifier acceptor 72, address determination part 73g, address transmitter 74, tunnel communication identifier generation

part 41, and tunnel communication identifier acceptor 76. Here, communication control unit 71, identifier acceptor 72, and address transmitter 74 are the same as those in embodiment 3, and tunnel communication identifier generation part 41 is the same as that in embodiment 7, and thus their descriptions are omitted.

Address determination part 73g determines a first address of first information-processing device 5 and a second address of second information-processing device 6, both used for communication target data in tunnel communication encapsulated in tunnel communication performed between first information-processing device 5 and second information-processing device 6, according to a first device identifier for identifying first information-processing device 5 and a second device identifier for identifying second information-processing device 6, both accepted by identifier acceptor 72, and to a tunnel communication identifier accepted by tunnel communication identifier acceptor 76. The method of determining an address is the same as that by address determination part 14e in embodiment 7, and thus its description is omitted.

Tunnel communication identifier acceptor 76 accepts a tunnel communication identifier. Tunnel communication identifier acceptor 76 may, for example, receive a tunnel communication identifier transmitted (from another server, for example) via wired or wireless communication lines, may accept a tunnel communication identifier having been input to server 7g through a given input device (e.g. keyboard, mouse, or touch panel), may accept a tunnel communication identifier read from a given recording medium (e.g. optical disc, magnetic disk, or semiconductor memory), or may accept a tunnel

communication identifier generated by server 7g. In this embodiment, a description is made for a case where accepting a tunnel communication identifier generated by tunnel communication identifier generation part 41 of server 7g. Here, tunnel communication identifier acceptor 76 may optionally include a device for accepting (e.g. modem or network card). Also, tunnel communication identifier acceptor 76 may be implemented by means of hardware, or software such as a driver for driving a given device.

Next, a description is made for the action of the communication system, in particular, the action for determining an address, according to this embodiment. Fig. 25 is a flowchart showing the action in which server 7g determines an address.

(S601) Identifier acceptor 72 judges whether the first device identifier and second device identifier have been accepted. If accepted, the flow goes to S602; otherwise, process S601 is repeated until they are accepted.

(S602) Address determination part 73g temporarily stores a first device identifier and second device identifier accepted by identifier acceptor 72 in a recording medium (not illustrated).

(S603) Tunnel communication identifier generation part 41 generates a tunnel communication identifier and passes the generated tunnel communication identifier to tunnel communication identifier acceptor 76.

(S604) Tunnel communication identifier acceptor 76 accepts the tunnel communication identifier passed from tunnel communication identifier generation part 41.

(S605) Address determination part 73g determines an address

according to the tunnel communication identifier accepted by tunnel communication identifier acceptor 76, and to the first device identifier and second device identifier, both accepted by identifier acceptor 72 and temporarily stored in a recording medium (not illustrated). This method of determining an address is the same as that in the concrete example in embodiment 7, and thus its description is omitted.

(S606) Address transmitter 74 transmits the addresses of first information-processing device 5 and second information-processing device 6, both determined by address determination part 73g, to first information-processing device 5 and second information-processing device 6, and then the flow returns to S601.

Here, in the flowchart of Fig. 25, the process ends with an interruption of power off or process end. Also, this flowchart illustrates a case where processes such as determining an address are performed when identifier acceptor 72 accepts a first device identifier and others. However, such a timing is not limited to this case, but an address may be determined when first information-processing device 5 and second information-processing device 6 start tunnel communication, using a first device identifier and others having been accepted by identifier acceptor 72 by that time, for example.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, data structure in tunnel communication is the same as that in Fig. 5. In addition, the IP addresses and device identifiers of information-processing devices and a server are assumed to be the same as those in the concrete example in embodiment 3. Further, the processes in which first information-processing device 5 and second

information-processing device 6 respectively register the IP addresses and device identifying information to server 7g are the same as that in embodiment 3, and thus their description are omitted.

Tunnel communication part 52 of first information-processing device 5 transmits a second device identifier for identifying second information-processing device 6 and a request for tunnel communication with second information-processing device 6, to server 7g. Then, they are received by communication control unit 71. Communication control unit 71 acquires an IP address of first information-processing device 5 from the header of a packet transmitted from first information-processing device 5, refers to the address identifier correspondence information shown in Fig. 11, and acquires the first device identifier "12345678" of first information-processing device 5. In addition, communication control unit 71 acquires the IP address "131.206.10.240" corresponding to the second device identifier "98765432" transmitted from first information-processing device 5, referring to the address identifier correspondence information. Then, communication control unit 71 passes the first device identifier and second device identifier to identifier acceptor 72, and also transmits the IP address of second information-processing device 6 to first information-processing device 5.

Identifier acceptor 72, when accepting the first device identifier and second device identifier from communication control unit 71 (S601), passes them to address determination part 73g. Address determination part 73g temporarily stores the first device identifier and others in a memory (not illustrated) (S602).

Further, tunnel communication identifier generation part 41, corresponding to a fact that communication control unit 71 has received information showing that tunnel communication is to be started, generates a new tunnel communication identifier "111222333" and passes the generated tunnel communication identifier to tunnel communication identifier acceptor 76 (S603). Consequently, the tunnel communication identifier is accepted by tunnel communication identifier acceptor 76 (S604).

After that, address determination part 73g determines IP addresses to be used by first information-processing device 5 and second information-processing device 6, according to the tunnel communication identifier accepted by tunnel communication identifier acceptor 76, and to the first device identifier and second device identifier stored in a memory (not illustrated), and then passes the determined address, making it correspond to the device identifier, to address transmitter 74 (S605). This method of determining an address is the same as that in the concrete example in embodiment 7, and thus its description is omitted.

Address transmitter 74, when receiving a set of the IP address of first information-processing device 5 determined by address determination part 73g, and the device identifier of first information-processing device 5; and a set of the IP address of second information-processing device 6, and the device identifier of the second information-processing device 6, refers to the address identifier correspondence information retained by communication control unit 71 to acquire IP addresses of information-processing devices corresponding to the respective device identifiers. Then, address

transmitter 74 transmits the two sets of the device identifiers and IP addresses to first information-processing device 5 and second information-processing device 6 (S606). The processes hereafter are the same as that in the concrete example in embodiment 3, and thus their descriptions are omitted.

As mentioned above, in the communication system according to this embodiment, server 7g can determine an address used for communication target data in tunnel communication performed between first information-processing device 5 and second information-processing device 6, according to the device identifier of an information-processing device and a tunnel communication identifier. This enables an address to be easily determined with a simple deterministic algorithm.

In this embodiment, the description is made for a case where address transmitter 74 transmits an address determined by address determination part 73g. However, an address output part for outputting an address determined by address determination part 73g may be equipped instead of address transmitter 74. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The address having been output may be set in first information-processing device 5 or second information-processing device 6, for example, by being recorded on a

given recording medium, or alternatively by being sent to the user of first information-processing device 5 or second information-processing device 6 by the administrator of server 7g via email, facsimile, or others.

Further, in this embodiment, the description is made for a case where address transmitter 74 of server 7g transmits two addresses determined by address determination part 73g to second information-processing device 6. However, address transmitter 74 may transmit only the address of second information-processing device 6 to second information-processing device 6. In this case, second information-processing device 6 can acquire an address of first information-processing device 5 from the header of encapsulated communication target data transmitted from first information-processing device 5.

In this embodiment, the description is made for a case where server 7g transmits both the addresses of first information-processing device 5 and second information-processing device 6. However, server 7g may first transmit the address of first information-processing device 5 to first information-processing device 5, and that of second information-processing device 6 to second information-processing device 6, and then transmit the address of the other party, when an inquiry related to the address of the other party in tunnel communication is made from an information-processing device.

(Embodiment 10)

A description is made for a communication system according to embodiment 10 of the present invention, referring to drawings. The communication system according to this embodiment determines an

address used for communication target data in tunnel communication, according to a determination related to whether the information-processing device is a caller or callee, and to a tunnel communication identifier for identifying tunnel communication.

The communication system according to this embodiment is assumed to be the same as that in Fig. 1 However, first information-processing device 1 is assumed to correspond to first information-processing device 1h; second information-processing device, to second information-processing device 2b in embodiment 4; and server 4, to server 4e in embodiment 7.

Fig. 26 is a block diagram showing the makeup of first information-processing device 1h according to this embodiment. First information-processing device 1h according to this embodiment is equipped with tunnel communication part 11, address determination part 14h, address transmitter 15, judgement part 16, and tunnel communication identifier acceptor 17. Here, tunnel communication part 11 and address transmitter 15 are the same as those in embodiment 1; judgement part 16, in embodiment 4; and tunnel communication identifier acceptor 17, in embodiment 7, and thus these descriptions are omitted.

Address determination part 14h determines an address used for communication target data encapsulated in tunnel communication, according to a determination by judgement part 16 and a tunnel communication identifier accepted by tunnel communication identifier acceptor 17. Here, tunnel communication identifier refers to an identifier for identifying tunnel communication performed between information-processing devices. In this address determination, it is

sufficient if an address used in a device (e.g. second information-processing device 2b) at the communication destination, and that in a device (e.g. first information-processing device 1h) at the communication source are determined differently, according to a determination by judgement part 16 and a tunnel communication identifier. Methods of determining an address include one with a given function used, and one by selecting from a plurality of predetermined addresses. In addition, address determination part 14h may determine a part of an address used for communication target data, according to a communication destination device identifier and communication source device identifier; and the other part of the address used for the communication target data, according to a tunnel communication identifier. A concrete example of a method of determining an address is described hereinafter. In determining an address, an address for a device for communication source and/or one for communication destination may be determined. In this embodiment, a description is made for a case where both addresses for a communication source and communication destination are determined.

Next, a description is made for the action of a communication system, in particular, the action in which first information-processing device 1h determines an address, according to this embodiment. Fig. 27 is a flowchart showing the action for determining an address in first information-processing device 1h.

(S701) Tunnel communication part 11 judges whether or not to start tunnel communication. To start this tunnel communication includes two cases: a case where first information-processing device 1h

actively starts tunnel communication, and a case where tunnel communication starts according to a request from another device (second information-processing device 2b, here). In either case, tunnel communication part 11 judges that tunnel communication is to be started. If started, the flow goes to S702; otherwise, repeats process S701 until tunnel communication is started.

(S702) Judgement part 16 judges whether first information-processing device 1h is a caller or callee.

(S703) Tunnel communication identifier acceptor 17 judges whether a tunnel communication identifier has been accepted. If accepted, the flow goes to S704; otherwise, repeats process S703 until a tunnel communication identifier is accepted.

(S704) Address determination part 14h determines an address using a determination by judgement part 16 and a tunnel communication identifier accepted by tunnel communication identifier acceptor 17. This method of determining an address is described hereinafter.

(S705) Address transmitter 15 transmits the address determined by address determination part 14h to second information-processing device 2b, and then the flow returns to S701.

Here, in the flowchart of Fig. 27, the process ends with an interruption of power off or process end. Still, this flowchart illustrates only a process for determining an address; however, it is obvious that this determined address is used for tunnel communication.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First,

the data structure in tunnel communication is the same as that in Fig. 5 in embodiment 1. In addition, the IP addresses and device identifiers of information-processing devices and a server are assumed to be the same as those in the concrete example in embodiment 1. Further, the processes in which first information-processing device 1h and second information-processing device 2b respectively register IP addresses and device identifying information to server 4e are the same as those in embodiment 1, and thus their descriptions are omitted.

It is assumed that a detachable recording medium with a communication destination device identifier recorded therein is attached to first information-processing device 1h, and the communication destination device identifier "98765432" stored in the recording medium is accepted by an acceptor (not illustrated) and is passed to tunnel communication part 11.

Then, tunnel communication part 11 judges that tunnel communication is to be started (S701), and transmits to server 4e the received communication destination device identifier and an instruction of transmitting an IP address of a device identified by the communication destination device identifier. Consequently, server 4e receives them to transmit the retained IP address "131.206.10.240", corresponding to the communication destination device identifier "98765432", to first information-processing device 1h. Tunnel communication part 11 of first information-processing device 1h, when accepting the IP address "131.206.10.240" of second information-processing device 2b from server 4e, retains the IP address.

Judgement part 16 judges that first information-processing device

1h is a caller because tunnel communication part 11 is a caller in communication for a protocol of tunnel in tunnel communication (S702), and then passes the determination to address determination part 14h.

In addition, server 4e judges that tunnel communication is started between first information-processing device 1h and second information-processing device 2b. Then, tunnel communication identifier generation part 41 generates the tunnel communication identifier "111222333" for identifying tunnel communication performed between first information-processing device 1h and second information-processing device 2b. Tunnel communication identifier transmitter 42 transmits the tunnel communication identifier to first information-processing device 1h. The address of first information-processing device 1h is one acquired from the header of a packet including a communication destination device identifier transmitted from first information-processing device 1h. The transmitted tunnel communication identifier "111222333" is accepted by tunnel communication identifier acceptor 17 of first information-processing device 1e (S703). The tunnel communication identifier is passed to address determination part 14h.

Address determination part 14h, when receiving a determination from judgement part 16, and a tunnel communication identifier from tunnel communication identifier acceptor 17, determines an IP address used for communication target data in tunnel communication, according to the determination and tunnel communication identifier. Specifically, address determination part 14h determines an address with either of the following two methods, for example (S704).

[Method of Determining an Address Using a Table]

The address determined by address determination part 14h has the structure shown in Fig. 28A. That is, the first eight bits show "169" and next eight bits, "254". The first four bits of the further next 16 bits indicates a network address, which is a remainder after dividing a tunnel communication identifier by "16,384". The last two bits show a host address, which is determined using the table of Fig. 28B. The table of Fig. 28B shows correspondence between information indicating a caller or callee and its IP address. First information-processing device 1h has been judged as a caller by judgement part 16, and thus address determination part 14h determines the host address of first information-processing device 1h as "1", using the table of Fig. 28B. Also, second information-processing device 2b is a callee, and thus address determination part 14h determines the host address of second information-processing device 2b as "2". Fig. 28B shows correspondence of information showing a caller or callee to an IP address in a tabular form. However, they may be made correspond with a means other than a tabular form. Further, the remainder "7741", after dividing the tunnel communication identifier "111222333" by "16,384", is a network address common to first information-processing device 1h and second information-processing device 2b. Therefore, address determination part 14h determines the IP address of first information-processing device 1h as "169.254.120.245". ("01111000111101", which is binary notation for "7741", and "01", which is binary notation for "1", are divided into eight bits each, "01111000" and "11110101". They are "120" and "245", respectively in decimal notation.) In the same way, address

determination part 14h determines the IP address of second information-processing device 2b as "169.254.120.246". Then, address determination part 14h passes these addresses to tunnel communication part 11 and address transmitter 15. Here, if addresses are determined in this way, "255.255.255.252" is used as a subnet mask in each information-processing device. As in this way where an address is determined using a table, address determination part 14h may determine a part of an address, according to a communication destination device identifier and communication source device identifier; and the other part of the address, according to a tunnel communication identifier.

Here, address determination part 14h may determine a host address by selecting from a plurality of predetermined addresses. One such example is that, when address determination part 14h has the table shown in Fig. 28C, and if the information-processing device is a caller, the host address may be selected from "1", "3", or "5", and if a callee, from "2", "4", or "6".

[Method of Determining an Address Using a Function]

Address determination part 14h has the function "Func(argument 1, argument 2)" for determining an address. When calculating an address of a caller, "0" is substituted for argument 1; a callee, "1" is substituted for argument 1. For argument 2, tunnel communication identifier is substituted. In this concrete example, it is assumed that address determination part 14h substitutes "0" for argument 1; "111222333" for argument 2; and the function returns the value "192.168.0.1". This IP address is to be that of first information-processing device 1h. Meanwhile, it is assumed that

address determination part 14h substitutes "1" for argument 1; "111222333" for argument 2; and the function returns the value "192.168.0.2". This IP address is to be that of second information-processing device 2b. Then, address determination part 14h passes these addresses to tunnel communication part 11 and address transmitter 15.

Here, the description is made for two different methods of determining an address. However, it is sufficient if address determination part 14h determines an address according to a determination by judgement part 16 and a tunnel communication identifier, and thus an address may be determined with a method of determining an address other than these.

Address transmitter 15, in the same way as in the concrete example in embodiment 1, transmits the determined IP addresses of first information-processing device 1h and second information-processing device 2b, to second information-processing device 2b (S705). Consequently, these IP addresses are accepted by address acceptor 21 in second information-processing device 2b and passed to tunnel communication part 22. Further, tunnel communication part 11, in the same way as in the concrete example in embodiment 1, performs tunnel communication using the determined address, and so does tunnel communication part 22 using the address accepted by address acceptor 21.

As mentioned above, the communication system according to this embodiment can determine an address used for communication target data in tunnel communication, according to a determination by judgement part 16 and a tunnel communication identifier for

identifying tunnel communication, which is a deterministic algorithm, simpler than a heuristic one. Consequently, this embodiment has the same advantage as embodiment 1.

In this embodiment, the description is made for a structure where first information-processing device 1h has address transmitter 15. However, first information-processing device 1h may have an address output part for outputting an address determined by address determination part 14h, instead of address transmitter 15. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The address having been output may be set in second information-processing device 2b, for example, by being recorded on a given recording medium, or by being sent to the user of second information-processing device 2b via email, facsimile, or the like.

In this embodiment, the description is made for a case where a tunnel communication identifier generated by server 4e is transmitted only to first information-processing device 1h. However, the tunnel communication identifier may be transmitted to second information-processing device 2b as well as to first information-processing device 1h.

(Embodiment 11)

A description is made for a communication system according to

embodiment 11 of the present invention, referring to drawings. In the communication system according to this embodiment, each information-processing device determines an address used for communication target data in tunnel communication, according to a determination related to whether each information-processing device is a caller or callee, and to a tunnel communication identifier.

Fig. 29 shows the makeup of the communication system according to this embodiment. The communication system according to this embodiment is equipped with first information-processing device 1i, second information-processing device 2i, and server 4e, all connected one another via communication line 3. Server 4e is the same as that in embodiment 7, and thus its description is omitted. However, in this embodiment, addresses are determined by first information-processing device 1i and second information-processing device 2i, and thus server 4e is to transmit the generated tunnel communication identifier to first information-processing device 1i and second information-processing device 2i, respectively.

First information-processing device 1i is equipped with tunnel communication part 11, address determination part 14h, judgement part 16, and tunnel communication identifier acceptor 17. Here, tunnel communication part 11, address determination part 14h, judgement part 16, and tunnel communication identifier acceptor 17 are the same as those in embodiment 10 , and thus their descriptions are omitted.

Second information-processing device 2i is equipped with tunnel communication part 22, address determination part 26i, judgement part 27, and tunnel communication identifier acceptor 28. Here,

tunnel communication part 22 is the same as that in embodiment 4; tunnel communication identifier acceptor 28, in embodiment 8; address determination part 26i, address determination part 14h in embodiment 10, and thus their descriptions are omitted.

In addition, the action in which first information-processing device 1i determines an address is the same as that shown in Fig. 27 in embodiment 10, except that the process for transmitting an address at S705 is not performed, and thus its description is omitted. Further, the action in which second information-processing device 2i in this embodiment determines an address is the same as that shown in Fig. 27 in embodiment 10, except that tunnel communication part 11, address determination part 14h, judgement part 16, and tunnel communication identifier acceptor 17 correspond to tunnel communication part 22, address determination part 26i, judgement part 27, and tunnel communication identifier acceptor 28 at S705, respectively, and that they do not transmit addresses, and thus their descriptions are omitted.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. Here, the action in which first information-processing device 1i determines an IP address is the same as that in the concrete example in embodiment 10, and thus its description is omitted. From server 4e, a tunnel communication identifier is assumed to be transmitted to second information-processing device 2i as well as to first information-processing device 1i.

Server 4e, according to a request from first information-processing device 1i, transmits an IP address of second information-processing

device 2i to first information-processing device 1i, and also information showing that first information-processing device 1i is requesting tunnel communication with second information-processing device 2i, to second information-processing device 2i. In addition, server 4e generates a tunnel communication identifier and transmits the tunnel communication identifier to first information-processing device 1i and second information-processing device 2i.

Tunnel communication part 22 of second information-processing device 2i, when receiving information transmitted from server 4e, judges that tunnel communication is to be started (S701), and judgement part 27 judges that second information-processing device 2i is a callee (S702). Tunnel communication identifier acceptor 28 accepts a tunnel communication identifier transmitted from server 4e through tunnel communication part 22 (S703). Here, the process in which address determination part 26i determines the IP addresses of first information-processing device 1i and second information-processing device 2i, according to a determination by judgement part 27 and a tunnel communication identifier is the same as that in embodiment 10, and thus its description is omitted. Also, the actions in which tunnel communication is performed after this address determination are the same as those in the concrete example in embodiment 10, except that an address is not transmitted, and thus its description is omitted.

As mentioned above, in the communication system according to this embodiment, each information-processing device can also determine an address used for communication target data in tunnel communication, according to a determination whether the

information-processing device is a caller or callee, and to a tunnel communication identifier. Each information-processing device determines its own address, thus dispensing with transmitting an address, bringing the same effect as that in embodiment 2.

In this embodiment, the description is made for a case where the addresses of a communication source and destination are determined by each information-processing device. However, when only the address of first information-processing device 1i is determined by itself, and when only the address of second information-processing device 2i is determined by itself, for example, they may be passed to the other party's information-processing device directly or indirectly.

(Embodiment 12)

A description is made for a communication system according to embodiment 12 of the present invention, referring to drawings. The communication system according to this embodiment determines an address used for communication target data in tunnel communication, according to a determination related to whether the information-processing device is a caller or callee, and to a tunnel communication identifier.

Fig. 30 shows the makeup of the communication system according to this embodiment. The communication system according to this embodiment is equipped with first information-processing device 5, second information-processing device 6, and server 7j, all connected one another via communication line 3 . Here, first information-processing device 5 and second information-processing device 6 are the same as those in embodiment 3, and thus their descriptions are omitted.

Server 7j, in the same way as server 4 in embodiment 1, performs a process to establish tunnel communication performed between first information-processing device 5 and second information-processing device 6, and also determines an address used in the tunnel communication, equipped with communication control unit 71, address determination part 73j, address transmitter 74, judgement part 75, tunnel communication identifier generation part 41, and tunnel communication identifier acceptor 76. Here, communication control unit 71 and address transmitter 74 are the same as those in embodiment 3; judgement part 75, in embodiment 6; tunnel communication identifier generation part 41 and tunnel communication identifier acceptor 76, in embodiment 9, and thus their descriptions are omitted.

Address determination part 73j determines a first address of first information-processing device 5 and a second address of second information-processing device 6, both used for communication target data in tunnel communication encapsulated in tunnel communication performed between first information-processing device 5 and second information-processing device 6, according to a determination by judgement part 75 and a tunnel communication identifier accepted by tunnel communication identifier acceptor 76. The method of determining an address is the same as that by address determination part 14h in embodiment 10, and thus its description is omitted.

Next, a description is made for the action of a communication system, in particular, the action for determining an address, according to this embodiment. Fig. 31 is a flowchart showing the action for determining an address in server 7j.

(S801) Communication control unit 71 judges whether tunnel communication between first information-processing device 5 and second information-processing device 6 is to be started. If started, the flow goes to S802; otherwise, repeats process S801 until tunnel communication is started.

(S802) Judgement part 75 judges whether first information-processing device 5 and second information-processing device 6 are a caller or callee, respectively.

(S803) Tunnel communication identifier generation part 41 generates a tunnel communication identifier and passes the generated tunnel communication identifier to tunnel communication identifier acceptor 76.

(S804) Tunnel communication identifier acceptor 76 accepts a tunnel communication identifier passed from the tunnel communication identifier generation part 41.

(S805) Address determination part 73j determines an address according to a tunnel communication identifier accepted by tunnel communication identifier acceptor 76 and a determination by judgement part 75. This method of determining an address is the same as that in the concrete example in embodiment 10, and thus its description is omitted.

(S806) Address transmitter 74 transmits the addresses of first information-processing device 5 and second information-processing device 6, both determined by address determination part 73j, to first information-processing device 5 and second information-processing device 6, and then the flow returns to S801.

Here, in the flowchart of Fig. 31, the process ends with an

interruption of power off or process end.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the data structure in tunnel communication is the same as that in Fig. 5. In addition, the IP addresses and device identifiers of information-processing devices and a server are assumed to be the same as those in the concrete example in embodiment 3. Further, the processes in which first information-processing device 5 and second information-processing device 6 respectively register IP addresses and device identifying information to server 7j are the same as those in embodiment 3, and thus their descriptions are omitted.

Next, tunnel communication part 52 of first information-processing device 5 transmits a second device identifier for identifying second information-processing device 6 and a request for tunnel communication with second information-processing device 6, to server 7j. Then, they are received by communication control unit 71. Communication control unit 71 judges that tunnel communication is to be started (S801), acquires an IP address of first information-processing device 5 from the header of a packet transmitted from first information-processing device 5, refers to the address identifier correspondence information shown in Fig. 11, and acquires the device identifier "12345678" of first information-processing device 5.

Communication control unit 71 further acquires the IP address "131.206.10.240" corresponding to the device identifier "98765432" transmitted from first information-processing device 5, referring to the address identifier correspondence information shown in Fig. 11. Then,

communication control unit 71 transmits the IP address of second information-processing device 6 to first information-processing device 5.

Judgement part 75, because communication control unit 71 has received information transmitted from first information-processing device 5, requesting tunnel communication with second information-processing device 6, judges that first information-processing device 5 is a caller and second information-processing device 6 is a callee (S802). Judgement part 75 then passes to address determination part 73j, information showing that the information-processing device identified by the device identifier "12345678" is a caller, and "98765432" is a callee.

Tunnel communication identifier generation part 41, corresponding to a fact that communication control unit 71 has received information showing that tunnel communication is to be started, generates a new tunnel communication identifier "111222333" and passes the generated tunnel communication identifier to tunnel communication identifier acceptor 76 (S803). Consequently, the tunnel communication identifier is accepted by tunnel communication identifier acceptor 76 (S804).

After that, address determination part 73j determines IP addresses to be used by first information-processing device 5 and second information-processing device 6, according to the tunnel communication identifier accepted by tunnel communication identifier acceptor 76, and to a determination received from judgement part 75, and passes the determined address, making it correspond to the device identifier, to address transmitter 74 (S805). This method of

determining an address is the same as that in the concrete example in embodiment 10, and thus its description is omitted.

Address transmitter 74, when receiving a set of the IP address of first information-processing device 5 determined by address determination part 73j and the device identifier of first information-processing device 5, and a set of the IP address of second information-processing device 6 and the device identifier of the second information-processing device 6, refers to the address identifier correspondence information retained by communication control unit 71 to acquire IP addresses of information-processing devices corresponding to the respective device identifiers. Then, address transmitter 74 transmits the two sets of the device identifiers and IP addresses to first information-processing device 5 and second information-processing device 6 (S806). The processes hereafter are the same as those in the concrete example in embodiment 3, and thus their descriptions are omitted.

As mentioned above, in the communication system according to this embodiment, server 7j can determine an address used for communication target data in tunnel communication performed between first information-processing device 5 and second information-processing device 6, according to a determination related to whether the information-processing device is a caller or callee, and to a tunnel communication identifier. This enables an address to be easily determined with a simple deterministic algorithm.

In this embodiment, the description is made for a case where address transmitter 74 transmits an address determined by address determination part 73j. However, an address output part for

outputting an address determined by address determination part 73j may be equipped instead of address transmitter 74. Here, this output may be, for example, display on a display device (e.g. CRT or liquid crystal display), transmission to a given device via communication lines, printing by a printer, recording on a given recording medium, or sound output by a speaker. The address output part may optionally include an output device (e.g. display device or printer). Also, the address output part may be implemented with hardware, or software such as a driver for driving such a device. The address having been output may be set in first information-processing device 5 or second information-processing device 6, for example, by being recorded on a given recording medium, or alternatively by being sent to the user of second information-processing device 6 by the administrator of server 7j via email, facsimile, or others.

Further, in this embodiment, the description is made for a case where address transmitter 74 of server 7j transmits two addresses determined by address determination part 73j to second information-processing device 6. However, address transmitter 74 may transmit only the address of second information-processing device 6 to second information-processing device 6. In this case, second information-processing device 2j can acquire an address of first information-processing device 5 from the header of encapsulated communication target data transmitted from first information-processing device 5.

In this embodiment, the description is made for a case where server 7j transmits both the addresses of first information-processing device 5 and second information-processing device 6. However, server

7j may first transmit the address of first information-processing device 5 to first information-processing device 5, and that of second information-processing device 6 to second information-processing device 6, and then transmit the address of the other party, when an inquiry related to the address of the other party in tunnel communication is made from an information-processing device.

In embodiments 9 and 12, the description is made for a case where tunnel communication identifier acceptor 76 accepts a tunnel communication identifier generated by tunnel communication identifier generation part 41. However, as aforementioned, tunnel communication identifier acceptor 76 may accept a tunnel communication identifier having been input by an input device, or a tunnel communication identifier read from a recording medium, for example.

(Embodiment 13)

A description is made for a communication system according to embodiment 13 of the present invention, referring to drawings. The communication system according to this embodiment, when detecting that two or more addresses used for communication target data in tunnel communication agree, changes such addresses.

Fig. 32 shows the makeup of the communication system according to this embodiment. The communication system according to this embodiment is equipped with first information-processing device 1k, second information-processing device 2b, third information-processing device 3k, and server 4, all connected one another via communication line 3 . Here, second information-processing device 2b is the same as that in embodiment 4; server 4, in embodiment 1, and thus their

descriptions are omitted.

First information-processing device 1k according to this embodiment is assumed to perform tunnel communication with two or more information-processing devices. In other words, first information-processing device 1k is assumed to perform tunnel communication with second information-processing device 2b and third information-processing device 3k. In such a case, if an address used for communication target data in tunnel communication between first information-processing device 1k and second information-processing device 2b is "192.168.0.1", and if that between first information-processing device 1k and third information-processing device 3k is "192.168.0.1", for example, the address with which first information-processing device 1k uses in tunnel communication with second information-processing device 2b, and third information-processing device 3k results in agreement. In tunnel communication, like communication using a virtual network interface, if addresses to be used agree, addresses allocated to the virtual network interface result in agreement. (Communication is performed using two NICs with an identical address, for example.) Consequently, first information-processing device 1k is unable to perform communication. In such a case, first information-processing device 1k according to this embodiment changes at least one address to enable itself to simultaneously perform two or more tunnel communications.

Fig. 33 is a block diagram showing the makeup of first information-processing device 1k according to this embodiment. First information-processing device 1k according to this embodiment is equipped with tunnel communication part 11, address determination

part 14b, address transmitter 15, judgement part 16, detection part 18, and address changing part 19. Here, tunnel communication part 11, address determination part 14b, address transmitter 15, and judgement part 16 are the same as those in embodiment 4, except that tunnel communication part 11 performs tunnel communication with two or more devices for communication destination, and that address transmitter 15 transmits a changed address as well, and thus their descriptions are omitted.

Detection part 18 detects in two or more tunnel communications that two or more addresses used for communication target data agree. For example, detection is performed for agreement of the address of first information-processing device 1k, that tunnel communication part 11 uses for communication target data in tunnel communication with second information-processing device 2b, and that with third information-processing device 3k

Address changing part 19, when detection part 18 detects two or more addresses agree, changes an address used for communication target data. Here, in this address change, only the address of first information-processing device 1k may be changed, or both the addresses of first information-processing device 1k and of an information-processing device as a communication destination for first information-processing device 1k may be changed, for example, out of the addresses used for communication target data in tunnel communication. Address changing part 19 may change some addresses out of two or more addresses that agree, so detected by detection part 18, so that these addresses do not agree (If two addresses agree, for example, only one address may be changed.), or

all the addresses may be changed. (If two addresses agree, for example, both addresses may be changed.) A concrete method of changing an address is described hereinafter.

Fig. 34 is a block diagram showing the makeup of third information-processing device 3k according to this embodiment. Third information-processing device 3k according to this embodiment is equipped with address acceptor 31 and tunnel communication part 32. Address acceptor 31 and tunnel communication part 32 are the same as address acceptor 21 and tunnel communication part 22 in second information-processing device 2b according to embodiment 4, respectively, and thus their descriptions are omitted.

Next, a description is made for the action of a communication system, in particular, the action for determining and changing an address, according to this embodiment. Fig. 35 is a flowchart showing the action for determining an address in first information-processing device 1k. Here, in the flowchart of Fig. 35, processes S301 through S304 are the same as those in the flowchart of Fig. 14, and thus their descriptions are omitted.

(S901) Detection part 18 judges whether two or more addresses used for communication target data agree in two or more tunnel communications performed by tunnel communication part 11. If detected as agreeing, the flow goes to S902; otherwise, returns to S301.

(S902) Address changing part 19 changes an address used for communication target data.

(S903) Address transmitter 15 transmits an address changed by address changing part 19. The destination to which this address is transmitted is an information-processing device that performs

communication related to the address changed by address changing part 19. If an address used for communication target data in tunnel communication with second information-processing device 2b has been changed, for example, the changed address is transmitted to second information-processing device 2b. If an address used for communication target data in tunnel communication with third information-processing device 3k has been changed, the changed address is transmitted to third information-processing device 3k. Then, the flow returns to S301.

Here, in the flowchart of Fig. 35, the process ends with an interruption of power off or process end. In addition, the flowchart of Fig. 35 shows a case where the processes related to address determination (S301 through S304) and those related to address change (S901 through S903) are performed separately. However, the following process may be performed. That is, judgement is made whether the addresses agree immediately after the addresses are determined. If the addresses do not agree, the address transmission process is performed; otherwise, the changed addresses are transmitted.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the data structure in tunnel communication is the same as that in Fig. 5. In addition, the IP addresses and device identifiers of information-processing devices and a server, are the same as those in the concrete example in embodiment 3. Further, the processes in which first information-processing device 1k, second information-processing device 2b, and third information-processing

device 3k respectively register IP addresses and device identifying information to a server are the same as those in embodiment 3, and thus their descriptions are omitted. The process in which tunnel communication is started between first information-processing device 1k and second information-processing device 2b is the same as that in embodiment 4, and thus its description is omitted. Also, the process in which tunnel communication is started between first information-processing device 1k and third information-processing device 3k is the same as that in embodiment 4, and thus its description is omitted. Here, it is assumed that the process for starting tunnel communication between first information-processing device 1k and third information-processing device 3k is executed, and in the tunnel communication, the IP address "192.168.0.1" of first information-processing device 1k, used for communication target data, has agreed with the IP address "192.168.0.1" of first information-processing device 1k, used for communication target data in tunnel communication with second information-processing device 2b.

Consequently, detection part 18 judges that both addresses agree (S901), and address changing part 19 changes an address used for communication target data in tunnel communication performed between first information-processing device 1k and third information-processing device 3k. Specifically, address changing part 19 changes an address with one of the following three methods, for example (S902). Here, the address is assumed to be "192.168.0.2" of third information-processing device 3k used for communication target data in tunnel communication performed between first

information-processing device 1k and third information-processing device 3k. Further, in this address, the last eight bits are assumed to represent a host address. (That is, the subnet mask is "255.255.255.0".)

[Method of Changing a Host Address]

Address changing part 19 adds "1" to the host address of the IP address "192.168.0.1" of first information-processing device 1k to determine the IP address of first information-processing device 1k as "192.168.0.2". Address changing part 19 also adds "1" to the host address of the IP address "192.168.0.2" of third information-processing device 3k to determine the IP address of third information-processing device 3k as "192.168.0.3".

[Method of Changing a Network Address]

Address changing part 19 adds "1" to the network address of the IP address "192.168.0.1" of first information-processing device 1k to determine the IP address of first information-processing device 1k as "192.168.1.1". Address changing part 19 also adds "1" to the network address of the IP address "192.168.0.2 of third information-processing device 3k to determine the IP address of third information-processing device 3k as "192.168.1.2".

[Method of Changing a Host Address and Network Address]

Address changing part 19 adds "1" to the network address of IP address "192.168.0.1" of first information-processing device 1k and to the host address to determine the IP address of first information-processing device 1k as "192.168.1.2". Address changing part 19 also adds "1" to the network address of the IP address "192.168.0.2" of third information-processing device 3k and to the host

address to determine the IP address of third information-processing device 3k as "192.168.1.3".

Here, the description is made for three different methods of determining an address. However, it is sufficient if address changing part 19 changes an address so as to resolve address agreement, and thus an address may be changed with an address change method other than these. For example, in this concrete example, only the IP address of first information-processing device 1k may be changed as long as it is possible that the IP addresses of first information-processing device 1k and third information-processing device 3k are not to agree.

In addition, if it is possible that a changed address is determined so as to be different from an address used for communication target data in tunnel communication with another information-processing device, the address may be determined again as a different one. In this case, if only the address of one information-processing device in tunnel communication is changed, it is required not to overlap with that of the other information-processing device in tunnel communication.

Address transmitter 15, in the same way as in the concrete example in embodiment 1, transmits the changed IP address of first information-processing device 1k and the IP address of third information-processing device 3k, to third information-processing device 3k (S903). Consequently, these IP addresses are accepted by address acceptor 31 in third information-processing device 3k and passed to tunnel communication part 32. Further, tunnel communication part 11 performs tunnel communication using the

changed address, and tunnel communication part 32 performs tunnel communication using the changed address accepted by address acceptor 31.

As mentioned above, in the communication system according to this embodiment, even if addresses used for communication target data in tunnel communication agree, they can be changed. Consequently, a situation can be avoided where two or more tunnel communications are disabled, enabling two or more tunnel communications to be performed appropriately.

Here, in this embodiment, namely a communication system according to embodiment 4, the description is made for a case where a first information-processing device is equipped with detection part 18 and address changing part 19. However, also in a communication system other than that in embodiment 4, an information-processing device may be equipped with a detection part and an address changing part. For example, in a communication system according to embodiments 7 and 10, when a first information-processing device performs tunnel communication with two or more devices where the first information-processing device is equipped with a detection part and an address changing part, if addresses used for communication target data agree, tunnel communication with two or more devices may be appropriately performed by changing at least one of the addresses.

(Embodiment 14)

A description is made for a communication system according to embodiment 14 of the present invention, referring to drawings. The communication system according to this embodiment changes an address in respective information-processing devices.

The communication system according to this embodiment is assumed to be the same as that in Fig. 32. However, first information-processing device 1k is assumed to correspond to first information-processing device 1m; second information-processing device 2b, to second information-processing device 2m.

Fig. 36 is a block diagram showing the makeup of first information-processing device 1m according to this embodiment. First information-processing device 1m according to this embodiment is equipped with tunnel communication part 11, address determination part 14b, judgement part 16, detection part 18, address changing part 19, and address change information transmitter 20. Here, tunnel communication part 11, address determination part 14b, judgement part 16 are the same as those in embodiment 4; detection part 18 and address changing part 19, in embodiment 13, and thus their descriptions are omitted.

Address change information transmitter 20, when detection part 18 detects two or more addresses agree, transmits address change information. Here, address change information refers to one related to change of an address used for communication target data in tunnel communication. Address change information may be one for only a direction to change an address, or one including a direction related to how to change an address. Address change information is transmitted to an information-processing device for communication destination performing tunnel communication for changing an address used for communication target data. Here, address change information transmitter 20 may optionally include a transmission device for transmitting (e.g. modem or network card). In this case, a

transmission device (not illustrated) is to exist between address change information transmitter 20 and communication line 3. Also, address change information transmitter 20 may be implemented by means of hardware, or software such as a driver for driving the transmission device.

Fig. 37 is a block diagram showing the makeup of second information-processing device 2m according to this embodiment. Second information-processing device 2m according to this embodiment is equipped with tunnel communication part 22, address determination part 26c, judgement part 27, address change information receiver 29, and address changing part 30. Here, tunnel communication part 22, address determination part 26c, judgement part 27 are the same as those in embodiment 5, and thus their descriptions are omitted.

Address change information receiver 29 receives address change information. Here, address change information receiver 29 may optionally include a receiving device for receiving (e.g. modem or network card). In this case, a receiving device (not illustrated) is to exist between address change information receiver 29 and communication line 3. Also, address change information receiver 29 may be implemented by means of hardware, or software such as a driver for driving the receiving device.

Address changing part 30, when address change information receiver 29 receives address change information, changes an address used for communication target data in tunnel communication. This process in which address changing part 30 changes an address is the same as that by address changing part 19 according to embodiment 13, and thus its description is omitted.

Next, a description is made for the action of a communication system, in particular, the action for determining and changing an address, according to this embodiment. Fig. 38 is a flowchart showing the action for determining and changing an address by first information-processing device 1m. Here, in Fig. 38, the processes other than that of S1001 is the same as those in the flowchart of Fig. 35 in embodiment 13, and thus their descriptions are omitted.

(S1001) Address change information transmitter 20 transmits address change information. The transmission destination of this address change information is an information-processing device for communication destination performing tunnel communication for changing an address used for communication target data. Here, in the flowchart of Fig. 38, the process ends with an interruption of power off or process end.

Fig. 39 is a flowchart showing the action for determining and changing an address by second information-processing device 2m. Here, in Fig. 39, the processes other than S1101 and S1102 are the same as those in the flowchart of Fig. 35 in embodiment 13, except that tunnel communication part 11 is tunnel communication part 22; address determination part 14b, address determination part 26c; judgement part 16, judgement part 27, and thus their descriptions are omitted.

(S1101) Address change information receiver 29 judges whether address change information has been received. If accepted, the flow goes to S1102; otherwise, returns to S301.

(S1102) Address changing part 30 changes an address used for communication target data in tunnel communication. After that,

tunnel communication part 22 is to perform tunnel communication using the changed address. Then the flow returns to S301.

Here, in the flowchart of Fig. 39, the process ends with an interruption of power off or process end.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the data structure in tunnel communication is the same as that in Fig. 5. In addition, the IP address and device identifiers of the information-processing devices and a server are assumed to be the same as those in the concrete example in embodiment 13. First, the process in which first information-processing device 1m and third information-processing device 3k start tunnel communication, and after that, first information-processing device 1m and second information-processing device 2m start tunnel communication, is the same as that in embodiment 5, and thus its description is omitted.

It is assumed that, after first information-processing device 1m and second information-processing device 2m start tunnel communication, the IP address of first information-processing device 1m, that first information-processing device 1m uses for communication target data in tunnel communication with third information-processing device 3k, and the IP address of first information-processing device 1m, that first information-processing device 1m uses for communication target data in tunnel communication with second information-processing device 2m, are both "192.168.0.1", and the agreement is detected by detection part 18 (S901). Consequently, address change information transmitter 20 transmits the address change information to second information-processing

device 2m (S1001). Further, address changing part 19 of first information-processing device 1m, in the same way as in embodiment 13, changes the IP address used for communication target data in tunnel communication with second information-processing device 2m (S902).

Address change information receiver 29 of second information-processing device 2m accepts address change information transmitted from first information-processing device 1m through tunnel communication part 22 (S1101). Then, address changing part 30 changes the IP address that second information-processing device 2m uses for communication target data in tunnel communication with first information-processing device 1m (S1102). This address change in address changing part 30 is to be made in the same way as in address changing part 19 in first information-processing device 1m. Therefore, even if addresses are changed separately in first information-processing device 1m and second information-processing device 2m, the changed addresses are assumed to be the same in first information-processing device 1m and second information-processing device 2m.

Here, address change information may include information showing how the addresses are to be changed. For example, when first information-processing device 1m performs address change where "1" is added to the host address of first information-processing device 1m and second information-processing device 2m, if address change information transmitter 20 transmits address change information including information showing the address change to second information-processing device 2m, second information-processing

device 2m can perform address change where "1" is added to the host address of first information-processing device 1m and second information-processing device 2m. Consequently, even if first information-processing device 1m and second information-processing device 2m separately change addresses, the changed addresses are identical.

As mentioned above, In the communication system according to this embodiment, when first information-processing device 1m detects that two or more addresses agree, second information-processing device 2m, as a result that the address is changed and also address change information is transmitted to second information-processing device 2m at the communication destination, can change an address in the same way as performed in first information-processing device 1m. Consequently, first information-processing device 1m and second information-processing device 2m can perform tunnel communication using the changed addresses, and also resolve the address agreement that has occurred in first information-processing device 1m.

Here, in this embodiment, namely a communication system according to embodiment 5, the description is made for a case where a first information-processing device is equipped with detection part 18 and others, and a second information-processing device is equipped with address change information receiver 29 and others. However, in a communication system other than that in embodiment 5, first information-processing device and others may be also equipped with detection part 18 and others. In a communication system according to embodiments 8 and 11, for example, as a result that first information-processing device and second information-processing

device are equipped with a detection part and an address changing part, when first information-processing device performs tunnel communication with two or more devices, tunnel communication with two or more devices may be appropriately performed by changing at least one of the addresses if an address used for communication target data agrees.

(Embodiment 15)

A description is made for a communication system according to embodiment 15 of the present invention, referring to drawings. In the communication system according to this embodiment, a server, when detecting that two or more addresses used for communication target data in tunnel communication agree, changes the address.

The communication system according to this embodiment is assumed to be the same as that in Fig. 32. However, first information-processing device 1k is assumed to correspond to first information-processing device 1n; second information-processing device 2b, to second information-processing device 2n; server 4, to server 7n. Here, third information-processing device 3k is assumed to be the same as in embodiment 13.

Fig. 40 is a block diagram showing the makeup of first information-processing device 1n according to this embodiment. First information-processing device 1n according to this embodiment is equipped with address acceptor 51, tunnel communication part 52, detection part 5, address agreement information transmitter 54, address change information receiver 55, and address changing part 56. Here, address acceptor 51 and tunnel communication part 52 are the same as those in embodiment 3, except that tunnel communication part

52 performs tunnel communication with two or more devices for communication destination, and detection part 53 is the same as detection part 18 in embodiment 13, and thus their descriptions are omitted.

Address agreement information transmitter 54, when detection part 53 detects two or more addresses agree, transmits address agreement information to server 7n. Here, address agreement information refers to information showing that addresses used for communication target data in tunnel communication agree. This address agreement information may include information showing in which tunnel communication the address used for communication target data has agreed with the address used for communication target data in other tunnel communication, for example. Here, address agreement information transmitter 54 may optionally include a transmission device for transmitting (e.g. modem or network card). In this case, a transmission device (not illustrated) is to exist between address agreement information transmitter 54 and communication line 3. Also, address agreement information transmitter 54 may be implemented by means of hardware, or software such as a driver for driving the transmission device.

Address change information receiver 55 receives address change information. Here, address change information refers to information related to address change. Address change information, as described in embodiment 13, for example, may be one for only a direction to change an address, one including a direction related to how to change an address (e.g. adding "1" to a host address), or one showing a changed address. Here, address change information receiver 55 may

optionally include a receiving device for receiving (e.g. modem or network card). In this case, a receiving device (not illustrated) is to exist between address change information receiver 55 and communication line 3. Also, address change information receiver 55 may be implemented by means of hardware, or software such as a driver for driving the receiving device.

Address changing part 56 changes an address used for communication target data. This address change is performed according to address change information received by an address change information receiver. If address change information is information showing how an address is changed, for example, address changing part 56 changes an address used for communication target data in tunnel communication according to the address change information.

Fig. 41 is a block diagram showing the makeup of second information-processing device 2n according to this embodiment. Second information-processing device 2n according to this embodiment is equipped with address acceptor 61, tunnel communication part 62, address change information receiver 63, and address changing part 64. Here, address acceptor 61 and tunnel communication part 62 are the same as those in embodiment 3, and thus their descriptions are omitted. Also, address change information receiver 63 and address changing part 64 are the same as address change information receiver 55 and address changing part 56 above-mentioned, respectively, and thus their descriptions are omitted.

Fig. 42 is a block diagram showing the makeup of server 7n according to this embodiment. Server 7n according to this embodiment is equipped with communication control unit 71, address

determination part 73d, address transmitter 74, judgement part 75, address agreement information receiver 77, address change information composition part 78, and address change information transmitter 79. Here, communication control unit 71, address determination part 73d, address transmitter 74, and judgement part 75 are the same as those in embodiment 6, and thus their descriptions are omitted.

Address agreement information receiver 77 receives address agreement information. Here, address agreement information receiver 77 may optionally include a receiving device for receiving (e.g. modem or network card). In this case, a receiving device (not illustrated) is to exist between address agreement information receiver 77 and communication line 3. Also, address agreement information receiver 77 may be implemented by means of hardware, or software such as a driver for driving the receiving device.

Address change information composition part 78, when address agreement information receiver 77 receives address agreement information, composes address change information. Address change information composition part 78 may, for example, generate new address change information or read address change information stored in a given recording medium or the like.

Address change information transmitter 79 transmits address change information composed by address change information composition part 78. Here, address change information transmitter 79 may optionally include a transmission device for transmitting (e.g. modem or network card). In this case, a transmission device (not illustrated) is to exist between address change information transmitter

79 and communication line 3. Also, address change information transmitter 79 may be implemented by means of hardware, or software such as a driver for driving the transmission device.

Next, a description is made for the action of a communication system, in particular, the action for determining and changing an address, according to this embodiment. Fig. 43 is a flowchart showing the action in which server 7n determines an address. Here, processes S401 through S404 are the same as those in the flowchart of Fig. 18 in embodiment 6, and thus their descriptions are omitted.

(S1201) Address agreement information receiver 77 judges whether address agreement information has been received. If received, the flow goes to S1202; otherwise, returns to S401.

(S1202) Address change information composition part 78 composes address change information.

(S1203) Address change information transmitter 79 transmits address change information composed by address change information composition part 78 to an information-processing device, and then the flow returns to S401.

Here, in the flowchart of Fig. 43, the process ends with an interruption of power off or process end.

Next, a description is made for the action of the communication system according to this embodiment, using a concrete example. First, the data structure in tunnel communication is the same as that in Fig. 5. In addition, the IP addresses and device identifiers of information-processing devices and a server are assumed to be the same as those in the concrete example in embodiment 13. First, the process in which first information-processing device 1n and third

information-processing device 3k start tunnel communication, and after that first information-processing device 1n and second information-processing device 2n start tunnel communication is the same as that in embodiment 14, and thus its description is omitted.

It is assumed that, after first information-processing device 1n and second information-processing device 2n start tunnel communication, the IP address of first information-processing device 1n, that first information-processing device 1n uses for communication target data in tunnel communication with third information-processing device 3k, and the IP address of first information-processing device 1n, that first information-processing device 1n uses for communication target data in tunnel communication with second information-processing device 2n, are both "192.168.0.1", and the agreement is detected by detection part 53. Consequently, address change information transmitter 54 transmits to server 7n, the address "192.168.0.1" of first information-processing device 1n and the address "192.168.0.2" of second information-processing device 2n, both used for communication target data in tunnel communication performed between first information-processing device 1n and second information-processing device 2n; and address agreement information including information showing that the address of first information-processing device 1n has agreed with an address to be used in other tunnel communication, and device identifying information of second information-processing device 2n.

Consequently, the address agreement information is received by address agreement information receiver 77 (S1201). Then, address change information composition part 78 judges that an address used

for the communication target data in tunnel communication performed between first information-processing device 1n and second information-processing device 2n, has agreed with an address used for the communication target data in other tunnel communication, and composes address change information for changing an address used for the communication target data in tunnel communication performed between first information-processing device 1n and second information-processing device 2n (S1202). This address change information is assumed to include a direction to add "1" to the host address. The address change information is transmitted to first information-processing device 1n and second information-processing device 2n by address change information transmitter 79 (S1203). Address change information transmitter 79 can learn the address of first information-processing device 1n, which is a transmission destination of the address change information, from the transmission source address of the address agreement information. Also address change information transmitter 79 can learn the address of second information-processing device 2n, by using the device identifying information of second information-processing device 2n, included in the address agreement information, and the address identifier correspondence information shown in Fig. 11.

The address change information is received by address change information receiver 55 of first information-processing device 1n, and address changing part 56 adds "1" to the IP address "192.168.0.1" of first information-processing device 1n and the IP address "192.168.0.2" of second information-processing device 2n, according to the address change information, to changes an address. Further, address change

information is received by address change information receiver 63 of second information-processing device 2n, and address changing part 64 of second information-processing device 2 also adds "1" to the IP address "192.168.0.1" of first information-processing device 1n and the IP address "192.168.0.2" of second information-processing device 2n, according to the address change information, to change an address. After that, tunnel communication is performed between first information-processing device 1n and second information-processing device 2n, using the changed address.

In this concrete example, the description is made for a case where address change information shows how an address is changed. However, address change information may show a changed address, and in such a case, address changing part 56 and others are to change the address of first information-processing device 1n and others to those shown by the address change information.

As mentioned above, in the communication system according to this embodiment, when first information-processing device 1n detects that two or more addresses agree, transmitting address agreement information showing two or more addresses have agreed to server 7n enables server 7n to be notified of the address agreement. After that, server 7n sends address change information to an information-processing device according to the reception of address agreement information, allowing each information-processing device to change an address according to the address change information. Consequently, first information-processing device 1n and second information-processing device 2n can perform tunnel communication using the changed address, and can also resolve the address agreement

that has occurred in first information-processing device 1n.

Here, in this embodiment, namely a communication system according to embodiment 6, the description is made for a case where first information-processing device is further equipped with address agreement information transmitter 54 and others, second information-processing device is further equipped with address change information receiver 63 and others, and a server is further equipped with address agreement information receiver 77 and others. However, also in a communication system in other than embodiment 6, as a result that a server and others are equipped with address agreement information receiver 77 and others, each information-processing device may change an address according to address change information transmitted from the server, in the same way as in this embodiment. In a communication system according to embodiments 9 and 12, for example, as a result that a server is equipped with an address agreement information receiver, address change information composition part, and address change information transmitter, when the first information-processing device performs tunnel communication with two or more devices, tunnel communication with two or more devices may be appropriately performed by changing at least one of the addresses if an address used for communication target data agrees.

In addition, in embodiments 13 through 15, the concrete example describes a case where an address is changed when two addresses agree. However, also when three or more addresses agree, the same address change process may be performed to resolve the address agreement.

Further, the concrete examples in each above-mentioned

embodiment describe a case where first information-processing device receives the device identifier of a second information-processing device from a recording medium. However, first information-processing device may receive the device identifier of a second information-processing device with another means such as input by an input device or reception via a communication line.

In addition, in each above-mentioned embodiment, a single or a plurality of communication control devices capable of NAT function (e.g. router) may exist between a first information-processing device and communication line 3, or between a second information-processing device and communication line 3. In this case, the communication control device is to perform IP address conversion and others.

In addition, in each above-mentioned embodiment, the description is made for a case where servers 4 and 7 are identified by their IP addresses. However, servers 4 and 7 may be identified by their domain names (e.g. "server.pana.net"). In this case, as a result that the domain name is converted by a DNS server, servers 4 and 7 can be identified.

Further, a protocol for communication performed through communication line 3 in each above-mentioned embodiment may be either IPv4 (Internet Protocol version 4) or IPv6 (Internet Protocol version 6).

In addition, in each above-mentioned embodiment, the description is mainly made for a case where a device identifier shown in numeric characters. However, a device identifier may be other characters such as alphabetical characters.

In addition, in each above-mentioned embodiment, each process

(each function) may be implemented by a centralized process with a single device (system) or a distributed process with a plurality of devices.

In addition, in each above-mentioned embodiment, each component may be composed of dedicated hardware, or software for a component feasible with software, namely by executing programs. One example is that a software program recorded in a recording medium such as a hard disk or semiconductor memory is read and executed by a program executing part such as a CPU, enabling each component to be implemented. Here, software for implementing an information-processing device or server in each above-mentioned embodiment, is the following program. That is, a program that makes a CPU execute an address determination step for determining an address used for communication target data encapsulated in tunnel communication performed between first information-processing device and second information-processing device, according to a first device identifier for identifying a first information-processing device and a second device identifier for identifying a second information-processing device.

This program may make a computer further execute an identifier accepting step for accepting a first device identifier and/or second device identifier, and may determine at the address determining step an address using the first device identifier and/or second device identifier accepted at the identifier accepting step.

In addition, another program is to make a computer execute a judging step for judging which is a caller or callee, a first information-processing device or second information-processing device,

performing tunnel communication; and an address determination step for determining an address used for communication target data encapsulated in tunnel communication performed between a first information-processing device and a second information-processing device, according to a determination by the judging step.

Further, another program is to make a computer execute an address determination step for determining an address used for communication target data encapsulated in tunnel communication performed between a first information-processing device and a second information-processing device, according to a first device identifier for identifying a first information-processing device; a second device identifier for identifying a second information-processing device; and a tunnel communication identifier for identifying tunnel communication performed between a first information-processing device and a second information-processing device.

In addition, this program may further make a computer execute an identifier accepting step for accepting a first device identifier and/or second device identifier, and at the address determining step, an address may be determined using a first device identifier and/or second device identifier accepted by the identifier accepting step.

Still, this program may further make a computer execute a tunnel communication identifier accepting step for accepting a tunnel communication identifier, and at the address determining step, an address may be determined using a tunnel communication identifier accepted at the tunnel communication identifier accepting step.

Further, another program is to make a computer execute a judging step for judging which is a caller or callee, a first

information-processing device or second information-processing device, performing tunnel communication; and an address determination step for determining an address used for communication target data encapsulated in tunnel communication performed between a first information-processing device and second information-processing device, according to a determination by the judging step, and to a tunnel communication identifier for identifying tunnel communication performed between a first information-processing device and a second information-processing device.

In addition, this program may further make a computer execute a tunnel communication identifier accepting step for accepting a tunnel communication identifier, and at the address determining step, an address may be determined using a tunnel communication identifier accepted at the tunnel communication identifier accepting step.

Further, another program is to make a computer execute a process in an information-processing device for communication source performing tunnel communication with two or more devices for communication destination, a program for making a computer execute a detecting step for detecting that two or more addresses agree that are used for each communication target data encapsulated in two or more tunnel communications; and an address changing step for changing an address used for communication target data when it is detected that two or more addresses agree at the detecting step.

Further, another program is to make a computer execute a process in an information-processing device for communication source performing tunnel communication with a device for communication destination, a program for making a computer execute an address

change information receiving step for receiving address change information that is information related to address change; and an address changing step for changing an address used for communication target data.

Further, another program is to make a computer execute a process in an information-processing device for communication source performing tunnel communication with two or more devices for communication destination, a program for making a computer execute a detecting step for detecting that two or more addresses agree that are used for each communication target data encapsulated in two or more tunnel communications; an address agreement information transmitting step for transmitting address agreement information that is information showing address agreement when it is detected that two or more addresses agree; an address change information receiving step for receiving address change information that is information related to address change; and an address changing step for changing an address used for communication target data, according to the address change information.

Further, another program is to make a computer execute: an address agreement information receiving step for receiving address agreement information that is information showing that two or more addresses agree that are used for communication target data encapsulated in two or more tunnel communications; an address change information composing step for composing address change information that is information related to address change so as to resolve the address agreement; and an address change information transmitting step for transmitting the address change information.

Here, in the above-mentioned program, the identifier accepting step for transmitting information and other steps do not include a process performed by hardware such as the process performed by an input device or the like (i.e. a process performed only by hardware).

In addition, this program may be executed by being downloaded from a server or the like, or being read from a given recording medium (e.g. optical disc, magnetic disk, or semiconductor memory)

Still, either a single or a plurality of computers may execute this program. In other words, either a centralized or distributed process may be performed.

INDUSTRIAL APPLICABILITY

As mentioned above, in a communication system and others according to the present invention, an address used for tunnel communication between information-processing devices with a simple algorithm, which is useful for a communication system performing tunnel communication, for example.